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8

Cumulative Impacts

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8. CUMULATIVE IMPACTS

The Council on Environmental Quality regulations that implement the procedural provisions of the National Environmental Policy Act of 1969, as amended (42 USC 4321 *et seq.*), define a cumulative impact as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (40 CFR 1508.7). Cumulative impacts can result from individually minor but collectively important actions taking place over a period of time. An evaluation of cumulative impacts is necessary to an understanding of the environmental implications of implementing the Proposed Action and is essential to the development of appropriate mitigation measures and the monitoring of their effectiveness.

This chapter evaluates the environmental impacts of repository activities coupled with the impacts of other Federal, non-Federal, and private actions. As part of this process, the chapter includes a detailed analysis of nuclear materials in need of permanent disposal in excess of those evaluated in the Proposed Action. It describes and evaluates these waste quantities, referred to as Inventory Modules 1 and 2, evaluated in terms of their environmental impacts in comparison with those of the Proposed Action impacts. The evaluation of these inventories provides sufficient information for future actions and decisionmaking on inventory selection. This chapter evaluates cumulative short-term impacts from the construction, operation and monitoring, and closure of a geologic repository at Yucca Mountain, and cumulative long-term impacts following repository closure. It also evaluates cumulative transportation impacts from the shipment of spent nuclear fuel and high-level radioactive waste to the repository and of other material to or from the repository. The analysis of cumulative transportation impacts includes the possible construction and operation in Nevada of a branch rail line, or of an intermodal transfer station along with highway improvements for heavy-haul trucks. In addition, the analysis considers cumulative impacts from the manufacturing of disposal containers and shipping casks.

The cumulative impact analysis in this chapter includes as a reasonably foreseeable future action the disposal in the proposed Yucca Mountain Repository of the total projected inventory of commercial spent nuclear fuel, U.S. Department of Energy (DOE) spent nuclear fuel, and high-level radioactive waste, as well as the disposal of commercial Greater-Than-Class-C waste and DOE Special-Performance-Assessment-Required waste. The total projected inventory of spent nuclear fuel and high-level radioactive waste is more than the 70,000 metric tons of heavy metal (MTHM) considered for the Proposed Action. Its emplacement at Yucca Mountain would require legislative action by Congress unless a second licensed repository was in operation.

There were several reasons to evaluate the potential for disposing of Greater-Than-Class-C waste and Special-Performance-Assessment-Required waste at Yucca Mountain as reasonably foreseeable actions. First, because both materials exceed Class C limits for specific radionuclide concentrations as defined in 10 CFR Part 61, they are generally unsuitable for near-surface disposal. Second, the U.S. Nuclear Regulatory Commission specifies in 10 CFR 61.55(a)(2)(iv) the disposal of Greater-Than-Class-C waste in a repository unless the Commission approved of disposal elsewhere. Finally, during the scoping process for this environmental impact statement (EIS), several commenters requested that DOE evaluate the disposal of other radioactive waste types that might require isolation in a repository. The disposal of Greater-Than-Class-C and Special-Performance-Assessment-Required wastes at the proposed Yucca Mountain Repository could require a determination by the Nuclear Regulatory Commission that these wastes require permanent isolation. In addition to spent nuclear fuel, high-level radioactive waste, surplus plutonium, Greater-Than-Class-C waste, and Special-Performance-Assessment-Required waste (materials such as depleted uranium), other radioactive wastes could be considered in the future for disposal in the Yucca Mountain Repository.

In general, the analysis of cumulative impacts in this chapter follows the process recommended in the Council on Environmental Quality's handbook *Considering Cumulative Effects Under the National Environmental Policy Act* (CEQ 1997, all). This process includes the identification, through research and consultations, of Federal, non-Federal, and private actions with possible effects that would be coincident with those of the Proposed Action on resources, ecosystems, and human communities. Coincident effects would be possible if the geographic and time boundaries for the effects of the Proposed Action and past, present, and reasonably foreseeable future actions overlapped. Using the methods and criteria described in Chapters 4, 5, and 6 of this EIS and their supporting appendixes, DOE assessed the potential cumulative impacts of coincident effects.

This chapter has five sections. Section 8.1 identifies and analyzes past, present, and reasonably foreseeable future actions with impacts that could combine with impacts of the Proposed Action. Sections 8.2 and 8.3 present the analyses of cumulative short-term (the period before the completion of repository closure) and long-term (the first 10,000 and first 1 million years following closure) impacts, respectively, in the proposed Yucca Mountain Repository region. Section 8.4 describes cumulative transportation impacts, nationally and in Nevada. Section 8.5 addresses cumulative impacts associated with the manufacturing of disposal containers and shipping casks.

8.1 Past, Present, and Reasonably Foreseeable Future Actions

This section identifies past, present, and reasonably foreseeable future actions with impacts that could combine with impacts of the Proposed Action. It describes these actions and their relationships to the Proposed Action that could result in cumulative impacts (see Table 8-1 for a summary). Sections 8.2 through 8.5 present the cumulative impacts from the past, present, and reasonably foreseeable future actions identified in this section.

8.1.1 PAST AND PRESENT ACTIONS

The description of existing (baseline) environmental conditions in Chapter 3 includes the impacts of most past and present actions on the environment that the Proposed Action would affect. This includes site characterization activities at Yucca Mountain. The impacts of past and present actions are, therefore, generally encompassed in the Chapter 4, 5, and 6 analyses of potential environmental impacts of the Proposed Action because the baseline for these analyses is the affected environment described in Chapter 3.

Two past actions that are not addressed in the Chapter 3 environmental baseline were identified for inclusion in the cumulative impact analysis in Sections 8.2, 8.3, and 8.4—past DOE activities at the Nevada Test Site (nuclear weapons testing, etc.) and past disposal of low-level radioactive waste at the Beatty Waste Disposal Area. Resources identified where past Nevada Test Site activities could add to impacts from the Proposed Action include air quality, groundwater, public health and safety, and transportation. For the Beatty Waste Disposal Site, the analysis included potential cumulative impacts from past transportation of waste to the Beatty site and from potential groundwater contamination.

8.1.2 REASONABLY FORESEEABLE FUTURE ACTIONS

This section describes the reasonably foreseeable future actions that the cumulative impacts analysis considered. The analysis included cumulative impacts from the disposal in the proposed repository of all projected spent nuclear fuel and high-level radioactive waste as well as Greater-Than-Class-C waste and Special-Performance-Assessment-Required waste as reasonably foreseeable future actions (Inventory Modules 1 and 2; see Section 8.1.2.2). Sections 8.1.2.3 and 8.1.2.4 describe other Federal, non-Federal, and private actions that could result in cumulative impacts. DOE did not analyze the No-Action

Table 8-1. Past, present, and reasonably foreseeable future actions that could result in cumulative impacts (page 1 of 2).

Action	Potential cumulative impacts			
	Impacts in the Yucca Mountain Repository region			
Name and description	Short-term (Section 8.2)	Long-term (Section 8.3)	Transportation (Section 8.4)[a]	Manufacturing (Section 8.5)
Past and present actions[b]				
Nevada Test Site				
Nuclear weapons testing, waste management, etc.	None	Air quality, groundwater, and public health and safety	Occupational and public radiological health and safety	None
Beatty Waste Disposal Area				
Low-level radioactive waste disposal	None	Groundwater	Occupational and public radiological health and safety	None
Reasonably foreseeable future actions				
Inventory Module 1[c]				
Disposal of all spent nuclear fuel and high-level radioactive waste in the proposed Yucca Mountain Repository	Same resources as the Proposed Action	Same resources as the Proposed Action	Same resources as the Proposed Action	Same resources as the Proposed Action
Inventory Module 2[c]				
Disposal of all spent nuclear fuel and high-level radioactive waste, as well as Greater-Than-Class C waste and Special-Performance-Assessment-Required waste, in the proposed Yucca Mountain Repository	Same resources as the Proposed Action	Same resources as the Proposed Action	Same resources as the Proposed Action	Same resources as the Proposed Action
Nellis Air Force Range				
National testing and training for military equipment and personnel	The Air Force is proposing no substantial new activities in the future at the Nellis Air Force Range.	The Air Force is proposing no substantial new activities in the future at the Nellis Air Force Range.	The Air Force is proposing no substantial new activities in the future at the Nellis Air Force Range.	The Air Force is proposing no substantial new activities in the future at the Nellis Air Force Range.
Nevada Test Site				
Defense (stockpile stewardship and management, material disposition, nuclear emergency response), waste management, environmental restoration, nondefense research and development, work for others	Air quality, groundwater, socioeconomics, public health and safety. (Note: The accident analysis of potential external events in Appendix H addresses the effects of possible future resumption of nuclear weapons tests).	Groundwater and public health and safety	Occupational and public radiological health and safety	None

Table 8-1. Past, present, and reasonably foreseeable future actions that could result in cumulative impacts (page 2 of 2).

Action	Potential cumulative impacts			
	Impacts in the Yucca Mountain Repository region			
Name and Description	Short-term (Section 8.2)	Long-term (Section 8.3)	Transportation (Section 8.4)[a]	Manufacturing (Section 8.5)
Reasonably foreseeable future actions (continued)				
DOE Complex-Wide Waste Management Activities Affecting the Nevada Test Site				
Treatment, storage, and disposal of low-level radioactive waste, mixed waste, transuranic waste, high-level radioactive waste, and hazardous waste from past and future nuclear defense and research activities	None[d]	Groundwater and public health and safety	Occupational and public radiological health and safety	None
Low-Level Waste Intermodal Transfer Station				
Construction and operation of an intermodal transfer station for the shipment of low-level radioactive waste to the Nevada Test Site near Caliente	None	None	Same resources as the Proposed Action (Caliente intermodal transfer station and highway route for heavy-haul trucks)	None
Timbisha Shoshone Reservation				
Creation of a discontiguous reservation in eastern California and southwestern Nevada for people of the Timbisha Shoshone Tribe	None	None	Water consumption, public safety, environmental justice	None
Cortez Pipeline Gold Deposit Projects				
Continued operation and potential expansion of a gold mine and processing facility	None	None	Land use and ownership (Carlin rail corridor)	None
Apex Bulk Commodities Intermodal Transfer Station				
Construction and operation of an intermodal transfer station for copper concentrate near Caliente	None	None	Same resources as the Proposed Action (Caliente intermodal transfer station and highway route for heavy-haul trucks)	None
Shared use of a DOE branch rail line				
Increase in rail operations and traffic resulting from rail service options for nearby mine operators and communities	None	None	Same resources as the Proposed Action	None

a. In addition to the specific actions identified in Section 8.1 and summarized in this table, the cumulative impacts for national transportation consider the occupational and public radiological health impacts of other past, present, and reasonably foreseeable future shipments of radioactive material.

b. The impacts of most past and present actions are included in the existing environmental baseline described in Chapter 3 and, therefore, are generally encompassed in the analysis of potential impacts of the Proposed Action in Chapters 4, 5, and 6. This includes site characterization activities at Yucca Mountain.

c. As described in Section 8.1.2.1, there would be essentially no difference in the design and operation of the repository for Inventory Module 1 or 2. Therefore, the cumulative impacts from Inventory Module 1 are generally considered the same as those from Inventory Module 2.

d. DOE waste management activities at the Nevada Test Site are included above for the continuation of waste management activities at current levels, plus additional wastes that could be received as a result of decisions based on the Waste Management Programmatic EIS (DOE 1997b, all). This includes cumulative impacts of transportation and disposal.

Alternative for cumulative impacts. Chapter 7, Section 7.3, describes the cumulative impacts for the No-Action Alternative. Chapters 2 and 7 contain details on this alternative and also on continued storage of the material at its current locations or at one or more centralized location(s). Interim storage is not analyzed for cumulative impacts because, as stated in Chapter 7, the potential for such storage is highly uncertain.

DOE gathered information on Federal, non-Federal, and private actions to identify reasonably foreseeable future actions that could combine with the Proposed Action to produce cumulative impacts. The types of documents reviewed included other EISs, resource management plans, environmental assessments, Notices of Intent, Records of Decision, etc. Consultations with Federal agencies, state and local agencies, and Native American tribes (see Appendix C) also contributed to the information used in the cumulative impact analysis.

8.1.2.1 Inventory Modules 1 and 2

Under the Proposed Action, DOE would emplace in the proposed Yucca Mountain Repository as much as 70,000 MTHM of spent nuclear fuel and high-level radioactive waste. Of the 70,000 MTHM, approximately 63,000 MTHM would be commercial spent nuclear fuel. The remaining 7,000 MTHM would consist of approximately 2,333 MTHM of DOE spent nuclear fuel and approximately 8,315 canisters (4,667 MTHM) containing solidified high-level radioactive waste. To determine the number of canisters of high-level radioactive waste included in the Proposed Action waste inventory, DOE used an equivalence of 0.5 MTHM per canister of defense high-level radioactive waste. DOE has consistently used the 0.5-MTHM-per-canister equivalence since 1985. Using a different approach would change the number of canisters of high-level radioactive waste analyzed. Regardless of the number of canisters, the impacts from the entire inventory of high-level radioactive waste are analyzed in this chapter. In addition, the 70,000 MTHM inventory would include 50 metric tons (55 tons) of surplus plutonium as spent mixed-oxide fuel or immobilized plutonium.

Inventory Modules 1 and 2 represent the reasonably foreseeable future actions of disposing of all projected commercial and DOE spent nuclear fuel and all high-level radioactive waste as well as Greater-Than-Class-C waste and Special-Performance-Assessment-Required waste in the proposed repository (see Figure 8-1). Under Inventory Module 1, DOE would emplace all projected commercial spent nuclear fuel (about 105,000 MTHM), all DOE spent nuclear fuel (about 2,500 MTHM), and all high-level radioactive waste (approximately 22,280 canisters). Inventory Module 2 includes the Module 1 inventory plus other radioactive material that could require disposal in a monitored geologic repository (commercial Greater-Than-Class-C waste and DOE Special-Performance-Assessment-Required waste). The estimated quantities of these other wastes are about 2,100 cubic meters (74,000 cubic feet) and about 4,000 cubic meters (140,000 cubic feet), respectively. Appendix A contains further details on these inventories.

The following paragraphs summarize the differences in repository facilities and operations to receive, package, and emplace the additional materials in Inventory Module 1 or 2. The information on Modules 1 and 2 in this section is from TRW (1999a,b,c, all) unless otherwise noted. Table 8-2 summarizes the increased number of shipments that would be required to transport the Module 1 or 2 inventory to the repository. As for the Proposed Action, the estimated numbers of shipments were based on the characteristics of the materials, shipping capabilities at the commercial nuclear sites and DOE facilities, the assumption that there would be one shipping cask per truck or railcar (a train would normally use multiple rail cars and ship more than one cask), various cask designs, and the transportation mode mix (mostly legal-weight truck or mostly rail). Appendix J contains additional details on Inventory Module 1 and 2 transportation requirements.

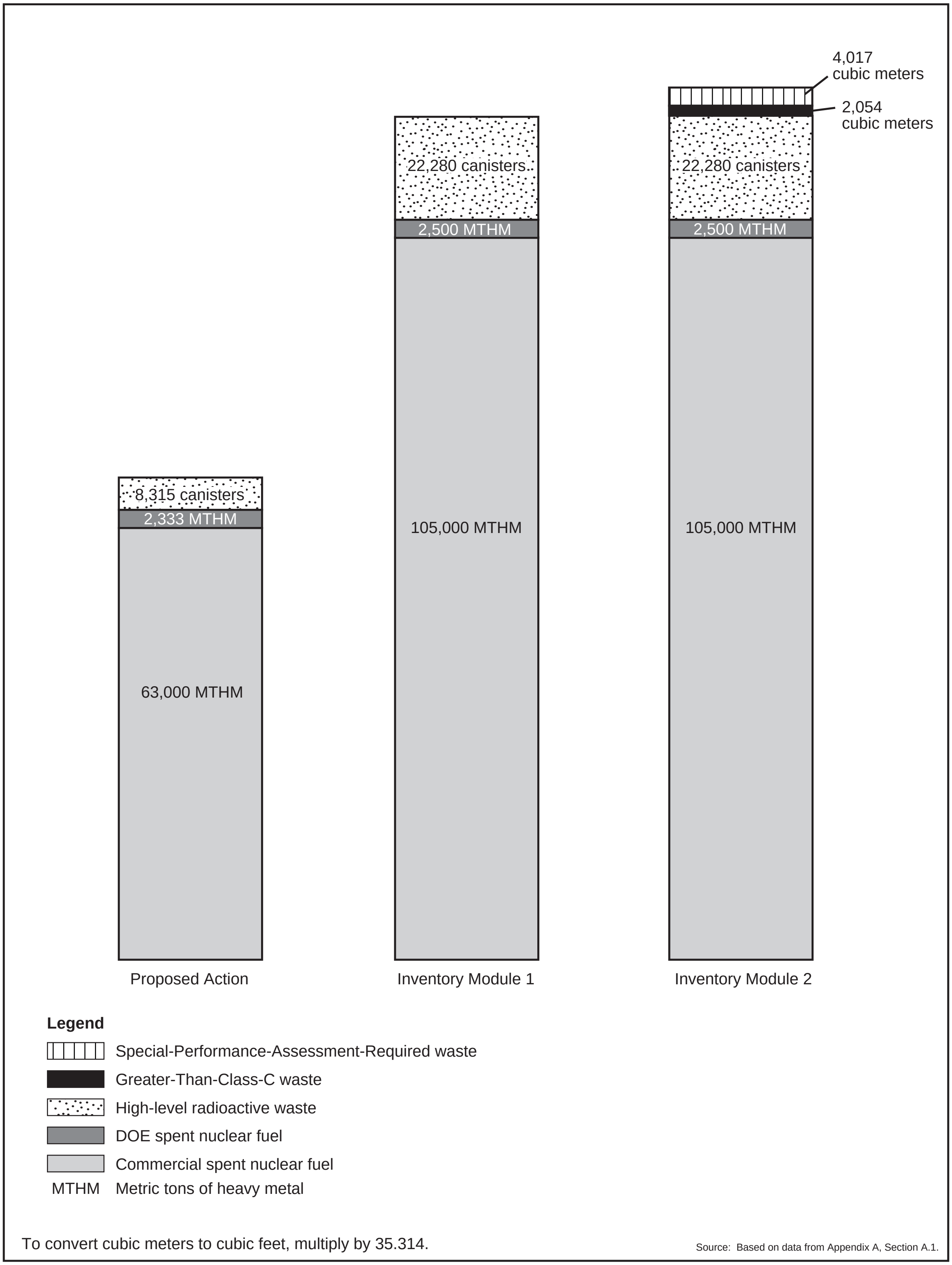

Figure 8-1. Proposed Action, Module 1, and Module 2 inventories evaluated for emplacement in a repository at Yucca Mountain.

Table 8-2. Estimated number of shipments for the Proposed Action and Inventory Modules 1 and 2.[a,b]

	Proposed Action				Module 1				Module 2			
	Mostly legal-weight truck		Mostly rail		Mostly legal-weight truck		Mostly rail		Mostly legal-weight truck		Mostly rail	
Material	Truck	Rail[c]	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Commercial SNF[d]	38,000	0	2,600	8,400	67,000	0	3,700	14,000	67,000	0	3,700	14,000
DOE SNF	3,500	300	0	770	3,700	300	0	800	3,700	300	0	800
HLW[e]	8,300	0	0	1,700	22,000	0	0	4,500	22,000	0	0	4,500
GTCC[f] waste	0	0	0	0	0	0	0	0	1,100	0	0	280
SPAR[g] waste	0	0	0	0	0	0	0	0	2,000	0	0	400
Totals	**50,000**	**300**	**2,600**	**11,000**	**93,000**	**300**	**3,700**	**19,000**	**96,000**	**300**	**3,700**	**20,000**

a. Source: Appendix J, Section J.1.3.1.
b. Totals might differ from sums due to rounding.
c. For this EIS, each combination of a shipping cask and railcar is assumed to be a single shipment.
d. SNF = spent nuclear fuel.
e. HLW = high-level radioactive waste.
f. GTCC = Greater-Than-Class-C.
g. SPAR = Special-Performance-Assessment-Required.

The following are the major differences between the repository facilities and operations for Inventory Modules 1 and 2 and those for the Proposed Action, which are described in Chapter 2:

- The longer time required to receive, package, and emplace the additional spent nuclear fuel, high-level radioactive waste, Greater-Than-Class-C waste, and Special-Performance-Assessment-Required waste, and to close the repository, for Inventory Module 1 or 2 versus that for the Proposed Action. The periods for the various project phases for Inventory Modules 1 and 2 would be the same.

- The need for more subsurface area to emplace about 17,000 to 19,000 waste packages for Inventory Module 1 and about 18,000 to 20,000 waste packages for Module 2 in comparison to about 10,000 to 11,000 waste packages for the Proposed Action (see Table 8-34)

Table 8-3 lists the differences in the expected time sequence for the repository construction, operation and monitoring, and closure phases for the Proposed Action and Inventory Module 1 or 2.

Table 8-3. Expected time sequence (years) of Yucca Mountain Repository phases for the Proposed Action and Inventory Module 1 or 2.[a]

		Operation and monitoring phase (2010-2110)				
Inventory	Construction phase (2005-2010)	Development[b]	Emplacement	Monitoring	Total	Closure phase (starts in 2110)
Proposed Action	5	22	24	76	100[c]	6-15[d]
Module 1 or 2	5	36	38	62	100	13-27[e]

a. Source: TRW (1999b, all); TRW (1998k,m,n,o,p,q,r,s,t,u,v, all); Jessen (1999b, all).
b. Continuing subsurface construction (development) activities are concurrent with emplacement activities.
c. Closure is assumed to begin 100 years following initial emplacement for the Proposed Action and Module 1 or 2 for the evaluation of cumulative impacts.
d. 6, 6, and 15 years for the high, intermediate, and low thermal load scenarios, respectively.
e. 13, 17, and 27 years for the high, intermediate, and low thermal load scenarios, respectively.

The amount of land required for surface facilities would increase only slightly for Inventory Module 1 or 2 from that for the Proposed Action (see Table 8-4). The design and operation of the repository surface facilities for Inventory Modules 1 and 2, including a Cask Maintenance Facility if it was at the Yucca Mountain site, would not differ much from those of the Proposed Action. The rate of material receipt, packaging, and emplacement would be approximately the same and would require an extra 14 years beyond the 24-year emplacement period for the Proposed Action. There would be no difference in the duration of the emplacement period between Inventory Modules 1 and 2 because the surface and subsurface facilities could accommodate the small number of additional shipments and waste packages for Module 2.

Table 8-4. Amount of land disturbed at the proposed Yucca Mountain Repository for the Proposed Action and Inventory Module 1 or 2 (square kilometers).[a,b,c]

Area	Proposed Action			Module 1 or 2		
	High thermal load	Intermediate thermal load	Low thermal load	High thermal load	Intermediate thermal load	Low thermal load
North Portal Operations Area[d]	0.62	0.62	0.62	0.62	0.62	0.62
South Portal Operations Area	0.15	0.15	0.15	0.15	0.15	0.15
Ventilation Shaft Operations Areas	0.02 (2 shafts)	0.02 (2 shafts)	0.06 (5 shafts)	0.02 (2 shafts)	0.04 (3 shafts)	0.06 (5 shafts)
Excavated rock storage area	1.02	1.17	1.15	1.17	1.40	2.00
Totals	**1.82**	**1.97**	**1.98**	**1.97**	**2.21**	**2.83**

a. Source: Jessen (1998, all).
b. To convert square kilometers to acres, multiply by 247.1.
c. Totals might differ from sums due to rounding.
d. The amount of land disturbance in the vicinity of the North Portal would vary slightly among the three packaging scenarios. The 0.62 square kilometer includes the surface facilities at the North Portal Operations Area and roads.

The repository subsurface facilities for Inventory Module 1 or 2 would require about 60 percent more subsurface excavation than the Proposed Action. About 5.0, 7.1, and 17 square kilometers (1,240, 1,750, and 4,200 acres) would be required for the high, intermediate, and low thermal load scenarios, respectively, for Module 1 or 2. This compares to 3.0, 4.25, and 10 square kilometers (740, 1,050, and 2,500 acres) for the high, intermediate, and low thermal load scenarios, respectively, for the Proposed Action (TRW 1999b, all). Additional subsurface area would be needed beyond the one to three blocks for the Proposed Action. DOE would characterize these blocks, which would be adjacent to the blocks identified for the Proposed Action, more fully before their use. The subsurface facilities would not differ between Inventory Modules 1 and 2 because the additional waste packages for Greater-Than-Class-C and Special-Performance-Assessment-Required wastes would be placed between commercial spent nuclear fuel waste packages. There would be no difference in emplacement operations for Inventory Module 1 or 2 from those described for the Proposed Action in Chapter 2. With the exception of the shorter duration after the completion of emplacement (62 rather than 76 years) (see Table 8-3), there would be no difference in monitoring and maintenance activities for Inventory Module 1 or 2 in comparison to the Proposed Action.

Because of the longer tunnels that would require the use of rock or other material to fill and seal the tunnels for Inventory Module 1 or 2, the duration of the closure phase would be longer, 6 to 15 years for the Proposed Action and 13 to 27 years for Module 1 or 2, depending on the thermal load scenario (see Table 8-3). Inventory Module 1 or 2 closure phase activities would not otherwise differ from those described in Chapter 2 for the Proposed Action.

8.1.2.2 Federal Actions

The following paragraphs describe reasonably foreseeable future actions of Federal agencies that could result in cumulative impacts in addition to those from Inventory Module 1 or 2.

Nellis Air Force Range

The Nellis Air Force Range in south-central Nevada (see Figure 8-2) is a national test and training facility for military equipment and personnel. The *Renewal of the Nellis Air Force Range Land Withdrawal Department of the Air Force Legislative Environmental Impact Statement* (USAF 1999, all) addresses the potential environmental consequences of the Air Force proposal to continue the Nellis Air Force Range

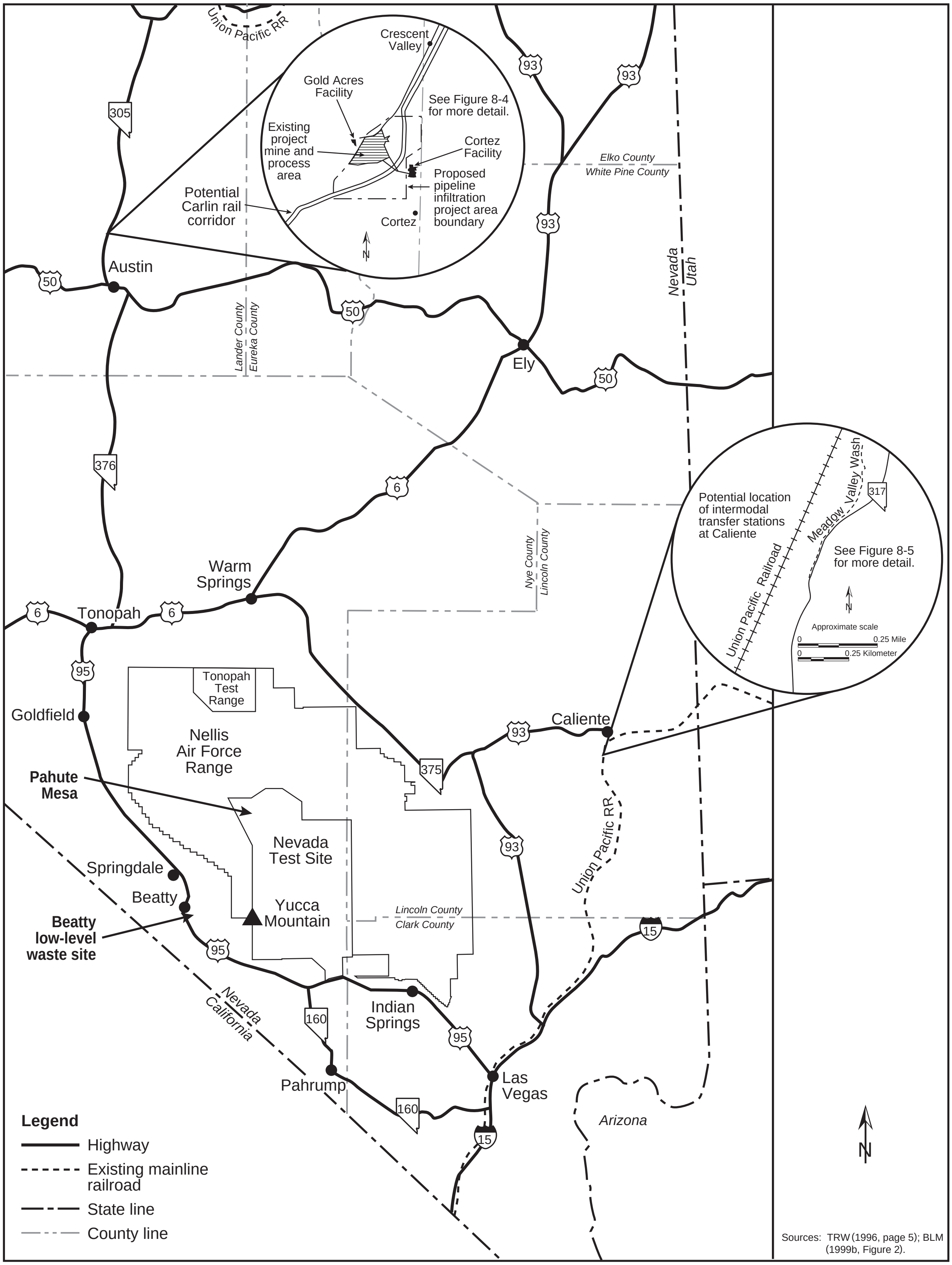

Figure 8-2. Locations of past, present, and reasonably forseeable future actions considered in the cumulative impact analysis.

land withdrawal for military use. The Air Force is proposing no substantial new activities in the future; the descriptions of the affected environment in Chapter 3 and the potential impacts of the Proposed Action in Chapters 4, 5, and 6 include the effects of present activities at the Nellis Air Force Range.

Nevada Test Site

The *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DOE 1996f, all) examines current and future DOE activities in southern Nevada at the Nevada Test Site, Tonopah Test Range, and sites the Department formerly operated in Nevada. The Record of Decision for that EIS (61 *FR* 65551, December 13, 1996) states that DOE would implement a combination of three alternatives: Expanded Use, No Action (continue operations at current levels) regarding mixed and low-level radioactive waste management, and Alternate Use of Withdrawn Lands regarding public education.

The Expanded Use Alternative incorporates all the activities and operations from ongoing Nevada Test Site programs and increases some of those programs. Activities of the Office of Defense Programs would expand at both the Nevada Test Site and the Tonopah Test Range, primarily in the areas of stockpile stewardship and management, materials disposition, and nuclear emergency response. As part of the Stockpile Stewardship and Management Program, there are continuing subcritical weapons test activities to study aging of weapons components and their reliability after aging. Waste management activities would continue at current levels pending decisions by DOE based on the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (DOE 1997b, all). Based on the preferred alternative in the programmatic EIS, this cumulative impact analysis included the additional low-level and mixed waste that could come to the Nevada Test Site. The Environmental Restoration Program would continue, potentially at an accelerated rate, at the Nevada Test Site and all offsite locations. Under the Work for Others Program, military use of the airspace over the Nevada Test Site and the Tonopah Test Range would increase, as would the use of certain lands on the Nevada Test Site by the military for training, research, and development. Public education activities would include the possible construction of a museum that highlights Nevada Test Site testing activities. The Nevada Test Site Development Corporation is considering the VentureStar® program initiative from the Lockheed Martin Corporation for a launch/recovery system that would link with the Kistler Aerospace Satellite launch and recovery project. The VentureStar® program would require two spaceports, a manufacturing and assembly facility, and a payload processing and administrative complex. These activities could occur in Areas 18, 22, and 23, respectively (Figure 8-3). Construction activities could begin in 2002 with an initial launch by 2004. Activities associated with VentureStar® and Kistler could result in the creation of as many as 2,500 jobs, road improvements, power upgrades, and a natural gas supply to the Nevada Test Site. However, there is not enough information at this time to perform a cumulative impacts analysis for this project.

The Nondefense Research and Development Program would continue to support ongoing program operations and pursue new initiatives, such as constructing and operating a solar power production facility (Solar Enterprise Zone facility) at the Nevada Test Site and a proposal by the Kistler Aerospace Corporation to use the Nevada Test Site for launching communication and other commercial and government satellites and recovering reusable launch vehicles.

An analysis of the environmental impacts presented in the Nevada Test Site EIS (DOE 1996f, all) and summarized in the DOE Record of Decision (61 *FR* 65551, December 13, 1996) (including impacts from weapons testing and the VentureStar®/Kistler project) identified the following resources for which impacts could overlap in relation to geography and timing with impacts from the proposed repository: air quality, groundwater, socioeconomics, public health and safety, and transportation. The effects on the Yucca Mountain Repository if a decision were made in the future to resume nuclear weapons testing or

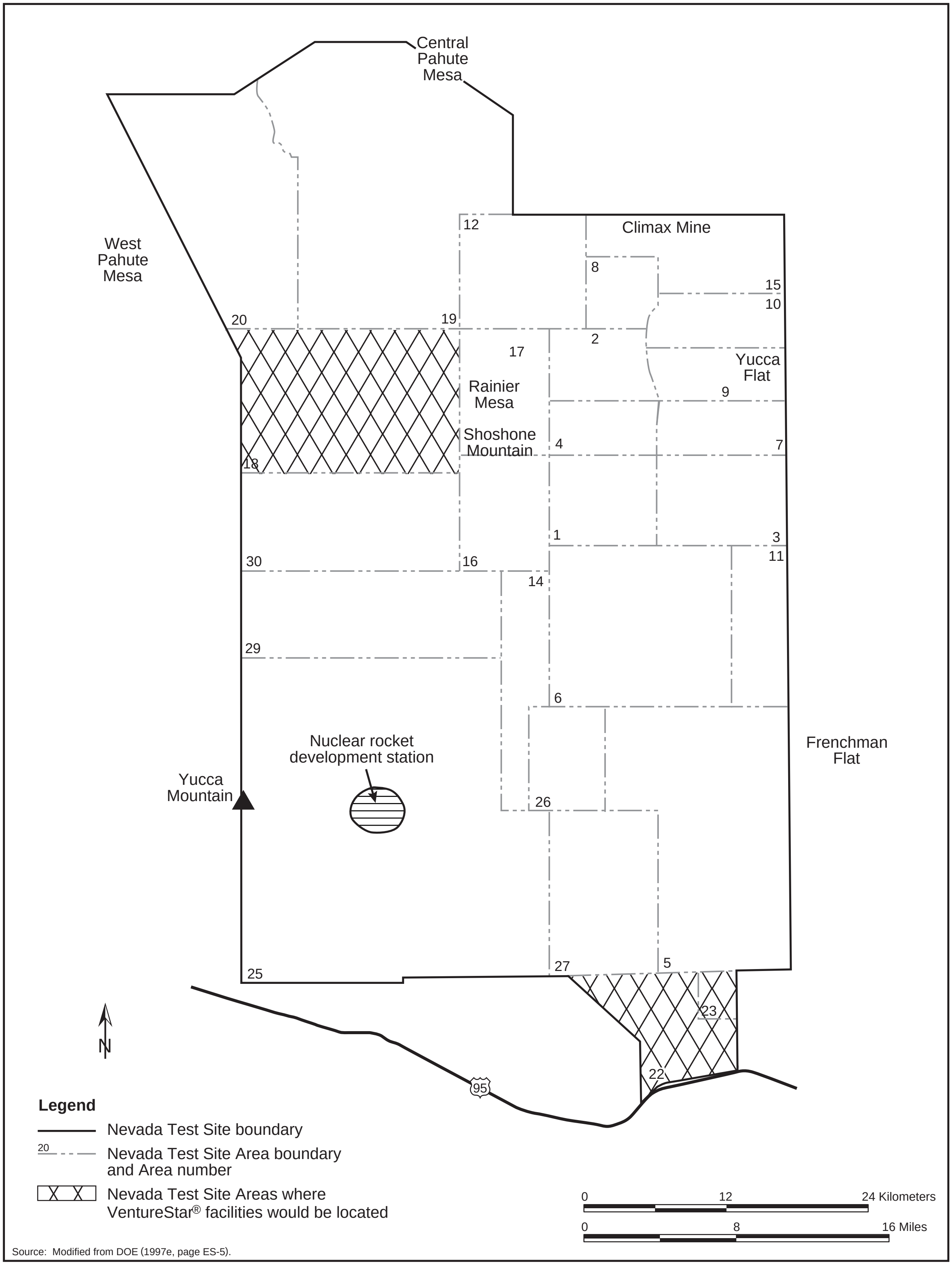

Figure 8-3. Potential locations of proposed cumulative activity associated with VentureStar® at the Nevada Test Site.

from a possible vehicle launch or recovery accident at the proposed VentureStar®/Kistler project are considered in the accident analysis of potential external events in Appendix H.

DOE Waste Management Activities

The Waste Management Programmatic EIS (DOE 1997b, all) evaluates the environmental impacts of managing five types of radioactive and hazardous wastes generated by past and future nuclear defense and research activities at a variety of DOE sites in the United States. The five waste types are low-level radioactive waste, mixed low-level waste (referred to in this EIS as simply mixed waste), transuranic waste, high-level radioactive waste, and hazardous waste. The Waste Management Programmatic EIS provides information to assist DOE with decisions on the management of, and facilities for, the treatment, storage, and disposal of these radioactive, hazardous, and mixed wastes.

Based on the Waste Management Programmatic EIS, DOE will make national, programmatic disposal decisions for both low-level waste and mixed waste. The DOE preferred alternative is to send its low-level radioactive waste and mixed waste to regional disposal sites after it is treated. After consultations with stakeholders, DOE plans to select two or three preferred sites from the following six: Hanford, Idaho National Environmental and Engineering Laboratory, Los Alamos National Laboratory, Nevada Test Site, Oak Ridge Reservation, and Savannah River Site. DOE could select the Nevada Test Site as a regional disposal site for low-level radioactive waste, mixed waste, or both with about 99 to 100 percent, respectively, of the waste being generated from non-Nevada Test Site generators. DOE waste management actions described in the Waste Management Programmatic EIS would have cumulative transportation impacts and, depending on the selected low-level radioactive waste and mixed waste disposal sites, potential cumulative short- and long-term impacts in the proposed Yucca Mountain Repository region.

In addition, based on the Waste Management Programmatic EIS, DOE will make national, programmatic decisions on the locations at which DOE will store immobilized high-level radioactive waste prior to its disposal at the proposed Yucca Mountain Repository. The DOE preferred alternative is to store its high-level radioactive waste at Hanford, the Idaho National Engineering and Environmental Laboratory, the Savannah River Site, and the West Valley Demonstration Project until acceptance at a geologic repository or other facility managed by DOE.

The *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (DOE 1997o, Chapter 5) identifies potential cumulative transportation impacts from the shipment of transuranic wastes from DOE sites across the United States, including the Nevada Test Site, to the Waste Isolation Pilot Plant in southeastern New Mexico for disposal.

Low-Level Waste Intermodal Transfer Station

DOE prepared a draft environmental assessment (DOE 1998m, all) on a proposed action to encourage low-level radioactive waste generators and their contractors to use transportation alternatives that would minimize radiological risk, enhance safety, and reduce the cost of waste shipments to the Nevada Test Site. However, DOE determined that there was no decision for it to make relative to transportation of low-level radioactive waste that would require a National Environmental Policy Act analysis, and therefore no longer plans to issue a National Environmental Policy Act document. DOE will publish a technical report which provides its low-level radioactive waste generators with a comparative risk analysis of alternative highway routes and intermodal transportation facilities.

Road improvements to accommodate legal-weight trucks and the construction of a rail siding or spur on a 0.02-square-kilometer (5-acre) site 1.2 kilometers (0.75 mile) south of Caliente would be needed for the low-level radioactive waste intermodal transfer station. Lifting equipment (crane or forklift) would transfer containers of low-level radioactive waste from railcars to trucks for transport to the Nevada Test

Site. Based on a 10-year average estimate of low-level waste volumes and shipments for the expanded use alternative from the Nevada Test Site EIS (DOE 1996f, pages 5-110 to 5-112), DOE expects the traffic through the intermodal transfer station to be less than 3 trains per day and about 14 trucks per day (7 outbound from the station and 7 returning from the Nevada Test Site). Intermodal transfer operations would occur only during daytime working hours, with containers dropped off during the night transported to the Nevada Test Site the following morning. A staff of three would be adequate to conduct operations at the station. Trucks would be inspected and decontaminated, as necessary, at the Nevada Test Site before returning to the station (DOE 1998m, pages 2-1 to 2-10 unless otherwise noted).

A high-end estimate for the planned trucking operation to support the low-level radioactive waste intermodal transfer station indicates a terminal on about 0.04 to 0.06 square kilometer (10 to 15 acres), a maintenance building 21 by 23 meters (70 by 75 feet), 9 tractors and 27 trailers, and 11 employees. One proposed location would be south and just outside of Caliente. Trucks would not pass through the Town of Caliente to reach the intermodal transfer station site (DOE 1998m, page 5-4).

The projections of low-level radioactive waste shipments from current DOE-approved generators to the Nevada Test Site do not extend to 2010 when shipments of spent nuclear fuel and high-level radioactive waste would begin to the proposed Yucca Mountain Repository. However, because it is reasonable to assume that low-level radioactive waste shipments to the Nevada Test Site could continue and occur coincidentally with shipments to the Yucca Mountain Repository, Section 8.4 analyzes the potential for cumulative impacts from the construction and operation of these two intermodal transfer stations as well as a privately owned intermodal transfer station described in the following section.

Proposed Timbisha Shoshone Reservation

The Secretary of the Interior has issued a draft report to Congress (Timbisha Shoshone and DOI 1999, all) describing a plan to establish a discontiguous reservation for people of the Timbisha Shoshone Tribe in portions of the Mojave Desert in eastern California and southwestern Nevada. The plan recommends a reservation that includes land at Furnace Creek in Death Valley National Park, four separated nearby parcels of Federally held land, two parcels of lands formerly allotted to Native Americans in the Saline Valley, California, and private lands near Lida, Nevada. The plan also proposes creating cooperative management and tribal use opportunities on other portions of the Tribe's ancestral homelands. Congress would have to pass legislation to create the reservation as proposed. The National Park Service of the U.S. Department of the Interior has issued a Notice of Scoping for environmental analysis on the proposal (64 *FR* 19193, April 19, 1999).

One of the parcels of land proposed for inclusion in the Timbisha reservation is near Scotty's Junction along U.S. 95 in Nevada, which is within 80 kilometers (50 miles) of the Yucca mountain site. The Carlin and Caliente rail corridor implementing alternatives follow a common course in this area and would overlap a portion of the parcel. Similarly, the Caliente heavy-haul implementing alternative, which would use U.S. 95, would pass through one part of the parcel and along the edge of another part.

The creation of a reservation is uncertain. The timing and final form of any reservation are speculative. There is insufficient information to assess quantitatively the potential for reservation activities to affect the environment. The report (Timbisha Shoshone and DOI 1999, all) contemplates a low overall level of activity for the reservation, which would tend to minimize the potential for impacts to the environment. The report does not describe specific activities proposed for the parcel near Scotty's Junction.

Because of the contemplated low level of use, the cumulative impacts probably would be very low. For example, the reservation proposal indicates that careful planning would occur to minimize water consumption, identifies no industrial or large-scale construction activities, and indicates that traffic patterns would not increase appreciably from the creation of the reservation. Therefore, cumulative impacts from the potential creation of this reservation do not appear to be large. Because the overall potential for cumulative impacts appears to be extremely low, the creation of a reservation would be unlikely to cause disproportionately high and adverse impacts to minority and low-income populations. If a reservation is created, DOE would work cooperatively with the Timbisha Shoshone Tribe and the government agencies directly concerned with reservation activities to minimize potential effects of transportation associated with a monitored geologic repository. The Final Yucca Mountain Repository EIS will assess information that becomes available on this project for additional impacts.

8.1.2.3 Non-Federal and Private Actions

The following paragraphs describe reasonably foreseeable future actions of non-Federal and private agencies or individuals that could result in cumulative impacts. This EIS considers the Cortez Pipeline Gold Deposit projects described below to be private actions even though they require the approval of the Bureau of Land Management.

Cortez Pipeline Gold Deposit Projects

An existing project, and two potential projects—the existing Cortez Gold Mine Pipeline Project, the proposed Pipeline Infiltration Project, and a possible Pipeline Southeast Expansion Project—are near the Carlin rail corridor of the Nevada transportation implementing rail alternative (see Chapter 2, Section 2.1.3.3). Cortez Gold Mine, Inc., operates the Pipeline Project mine and processing facility and plans to operate it through 2004. The environmental impacts of the existing mining operation are discussed in the *Cortez Pipeline Gold Deposit: Final Environmental Impact Statement* (BLM 1996, all). The proposed Pipeline Infiltration Project would expand the Pipeline Project area to add additional land for the construction and operation of infiltration ponds to support the existing mine (BLM 1999b, all). Cortez Gold Mines is studying a Pipeline Southeast Expansion Project (BLM 1996, page 5-7) that would expand mining operations southeast of the existing gold mine and would extend the life of the existing processing facility. Based on an analysis of the general area potentially affected by the Cortez Gold Mine projects, there could be cumulative land-use and ownership impacts with the Carlin branch rail line (see Figure 8-2).

Apex Bulk Commodities Intermodal Transfer Station

Apex Bulk Commodities is negotiating with BHP Copper of Ely, Nevada, to build an intermodal transfer station at Caliente near the potential intermodal transfer station site for shipping spent nuclear fuel and high-level radioactive waste to the proposed Yucca Mountain Repository. Apex anticipates one diesel truck per hour carrying 40 tons of copper concentrate, 24 hours per day, for 15 years. An improved access road and about 4,200 meters (14,000 feet) of new rail would be constructed. The transfer facility would be housed in a building 90 by 30 meters (300 by 100 feet) designed to retain dust, water, and spills generated during the transfer process. Air emission particulates would be collected in two baghouses. Apex would also need a truck maintenance facility, which would be in a building 30 by 18 meters (100 by 60 feet). An above-ground storage tank for about 45,000 liters (12,000 gallons) of diesel fuel is also planned. Apex estimates 25 new jobs for Caliente and an annual payroll of $800,000 (DOE 1998m, page 5-5).

Although a start date for Apex copper concentration intermodal transfer station and truck transportation operations is unknown, Section 8.4 analyzes the potential for cumulative impacts from the construction and operation of that station, assuming these activities would coincide with impacts from the Nevada Test Site low-level radioactive waste intermodal transfer station and the intermodal transfer station for shipments to the proposed Yucca Mountain Repository.

Shared Use of a DOE Branch Rail Line

If DOE built a branch rail line to transport spent nuclear fuel and high-level radioactive waste to the Yucca Mountain Repository, it could share the use of this line with others. A branch rail line in the Carlin corridor could provide transportation service options for mine operators in the central mountain valleys of Nevada and could provide freight service options for southwestern Nevada communities such as Tonopah, Beatty, Goldfield, and Pahrump. A branch rail line in the Caliente corridor could serve those communities plus Warm Springs, along with mine operators in the interior of Nevada. A Caliente-Chalk Mountain branch line could provide rail service to Nevada mines in the interior. A branch rail line in the Valley Modified or Jean corridors would provide freight service access to farms, industries, and businesses in the Amargosa Valley and Pahrump communities. A Valley Modified branch line would also provide rail service to the Indian Springs community. Any of the potential branch rail lines to the Yucca Mountain site (see Chapter 6, Figure 6-10) would provide rail access to the Nevada Test Site. The shared use of a branch rail line would have positive economic benefits, but could produce cumulative impacts due to increased operations and traffic.

8.2 Cumulative Short-Term Impacts in the Proposed Yucca Mountain Repository Region

This section describes short-term cumulative impacts during the construction, operation and monitoring, and closure of the repository in the regions of influence for the resources the repository could affect. DOE has organized the analysis of cumulative impacts by resource area. As necessary, the discussion of each resource area includes cumulative impacts from Inventory Module 1 or 2; from other Federal, non-Federal, and private actions; and from the combination of Inventory Modules 1 and 2 and other Federal, non-Federal, and private actions. Table 8-5 summarizes these impacts. The impacts listed for the Proposed Action in Table 8-5 include the combined effects of the potential repository and transportation activities.

There would be essentially no difference in the design and operation of the repository for Inventory Modules 1 and 2. As described in Appendix A, the radioactive inventory for Greater-Than-Class-C waste and for Special-Performance-Assessment-Required waste is much less than that for spent nuclear fuel and high-level radioactive waste. The subsurface emplacement of the material in Inventory Module 2, in comparison with the inventory for Module 1, would not greatly increase radiological impacts to workers or the public (TRW 1999b, page 6-44). For the surface facilities, the number of workers and the radiological exposure levels would be the same for Inventory Modules 1 and 2 (TRW 1999a, Tables 6-1, 6-2, 6-4, and 6-5). Therefore, DOE did not perform separate analyses for Modules 1 and 2 to estimate the short-term impacts. This section identifies the short-term impacts as being for Modules 1 and 2, indicating that the impacts for the two modules would not differ greatly.

DOE performed quantitative calculations for long-term impacts for both modules (see Section 8.3.1). The conclusion from these quantitative estimates was that the long-term impacts for Modules 1 and 2 would not differ greatly.

8.2.1 LAND USE AND OWNERSHIP

The ownership, management, and use of the analyzed land withdrawal area described in Chapter 4, Section 4.1.1 for the Proposed Action would not change for Inventory Module 1 or 2. The amount of land required for surface facilities would increase somewhat for Module 1 or 2 because of the larger storage area for excavated rock and an additional ventilation shaft for the intermediate thermal load scenario (see Table 8-4). This would have no substantial cumulative land-use or ownership impact.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 1 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Land use and ownership	Withdraw about 600 square kilometers (150,000 acres) of land already under Federal control by DOE, U.S. Air Force, and Bureau of Land Management. Public access to about 200 square kilometers (50,000 acres) of BLM public lands would be terminated. About 3.5 square kilometers (870 acres) of withdrawn land would be disturbed. As much as 20 square kilometers (4,900 acres) of land would be disturbed along transportation routes in Nevada, a portion of which would be in the Yucca Mountain region and could include the need for rights-of-way agreements or withdrawals.	Land withdrawal impacts would be the same as those for the Proposed Action. As much as 1 square kilometer (250 acres) of additional land would be disturbed, for a total of as much as 4.5 square kilometers (1,100 acres). Land use and ownership impacts from transportation would be the same as for the Proposed Action.	No other actions were identified with potential cumulative land-use and ownership impacts in the region of influence of repository construction, operation and monitoring, and closure. An intermodal transfer station could be constructed for shipping low-level radioactive waste within the Yucca Mountain region.	Withdraw about 600 square kilometers (150,000 acres) of land already under Federal control by DOE, U.S. Air Force, and Bureau of Land Management. Public access to about 200 square kilometers (50,000 acres) of BLM public lands would be terminated. As much as 4.5 square kilometers (1,100 acres) of withdrawn land would be disturbed. As much as 20 square kilometers (4,900 acres) of land would be disturbed along transportation routes in Nevada, a portion of which would be in the Yucca Mountain region and could include the need for rights-of-way agreements or withdrawals.
Air Quality				
Nonradiological	Criteria pollutant [nitrogen dioxide, sulfur dioxide, carbon monoxide, and particulate matter (PM_{10}, $PM_{2.5}$)] and cristobalite concentrations calculated at the analyzed land withdrawal area boundary would be less than 5 percent of applicable regulatory limits (see Tables 8-6, 8-7, and 8-8). Emissions associated with transportation in the proposed repository region would be low.	Criteria pollutant and cristobalite concentrations calculated at the analyzed land withdrawal area boundary would be less than 5 percent of applicable regulatory limits (see Tables 8-6, 8-7, and 8-8). Emissions associated with transportation in the proposed repository region would be low.	**Nevada Test Site:** Baseline monitoring shows that criteria pollutants at the Nevada Test Site and in the proposed repository region are well below National Ambient Air Quality Standards and would result in very small cumulative nonradiological air quality impacts. Emissions associated with the transportation of waste, people, and materials for Nevada Test Site activities in the repository region would be low.	Criteria pollutant and cristobalite concentrations calculated at the analyzed land withdrawal area boundary would be small fractions of applicable regulatory limits (generally less than 10 percent). Emissions associated with transportation in the repository region would be low.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 2 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Air Quality (continued)				
Radiological	The maximally exposed individual in the public would receive an estimated annual radiation dose of 1.5 millirem or less (see Tables 8-9, 8-10, and 8-11), primarily from naturally occurring radon.	The maximally exposed individual in the public would receive an estimated annual dose of 2.4 millirem or less, primarily from naturally occurring radon.	**Nevada Test Site:** Activity would continue to contribute extremely small increments to the risk to the general population and should not increase injury or mortality rates. As an example, the maximally exposed individual in the public would receive an estimated annual radiation dose of 0.09 millirem from past, present and reasonably foreseeable future activities.	The maximally exposed individual in the public would receive an annual radiation dose of 2.5 millirem or less, which is well below the 40 CFR 61 limit of 10 millirem[b] from radioactive material releases from the repository and the Nevada Test Site.
Hydrology				
Surface water	About 3.5 square kilometers (870 acres) of land would be disturbed and resulting impacts would likely be small and limited to the site. Impacts from construction and use of transportation capabilities (heavy-haul and rail) in the site vicinity and region would result in small impacts to surface water. Minor changes to runoff and infiltration rates. Floodplain/wetlands assessment concluded impacts would be small. Transportation floodplain/wetlands assessments would be performed in the future as necessary.	Would be similar to impacts from the Proposed Action with an increase of as much as 1 square kilometer (250 acres) in surface disturbance for a total of as much as 4.5 square kilometers (1,100 acres). Impacts from construction and use of transportation capabilities (heavy-haul and rail) would be small. Minor changes to runoff and infiltration rates. Floodplain/wetlands assessment concluded impacts would be small. Transportation floodplain/wetlands assessments would be performed in the future as necessary.	No other actions were identified with potential cumulative surface-water impacts within the region of influence of repository construction, operation and monitoring, and closure. Transportation impacts would be small.	As much as 4.5 square kilometers (1,100 acres) of land would be disturbed and resulting impacts would likely be minor and limited to the site. Impacts from construction and use of transportation capabilities (heavy-haul and rail) in the site vicinity and region would result in small impacts to surface water. Minor changes to runoff and infiltration rates. Floodplain/wetlands assessment concluded impacts would be small. Transportation floodplain/wetlands assessments would be performed in the future as necessary.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 3 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Hydrology (continued)				
Groundwater	Annual water demand (well below Nevada State Engineer's ruling on perennial yield) would be between 250 and 480 acre-feet (during emplacement) below the lowest estimate of perennial yield of the western two-thirds of the Jackass Flats basin (580 acre-feet). Water use for the construction of a rail line could be as much as 710 acre-feet from multiple wells and hydrographic areas over 2.5 years.	Anticipated annual water demand (below Nevada State Engineer's ruling on perennial yield) would be similar to that of the Proposed Action, but the highest demand, which would occur when emplacement and development activities occurred together, would extend for an additional 14 years. Water use for transportation would be the same as that for the Proposed Action.	**Nevada Test Site:** Anticipated annual water demand from Nevada Test Site activities would be about 280 acre-feet, which is less than the estimate of perennial yield of the western two-thirds of the Jackass Flats basin (580 acre-feet).	Combining the highest annual water demand of the repository of 480 acre-feet (during emplacement and development activities for the low thermal load scenario) with annual water withdrawals from the Nevada Test Site of 280 acre-feet would result in a total of 760 acre-feet, which would exceed the lowest estimate of perennial yield of the western two-thirds of the Jackass Flats basin (580 acre-feet), but would not approach the highest estimate of perennial yield, which is between 880 and 4,000 acre-feet. There is a potential for drawdown of the nearby aquifer from water withdrawal. The combined peak annual water use of a repository under an intermediate or high thermal load scenario with Nevada Test Site annual water use would result in a maximum peak cumulative use of about 530 acre-feet per year, which is below the perennial yield of the western two-thirds of the Jackass Flats basin (580 acre-feet). In addition, up to 710 acre-feet of water would be used to construct a rail line in Nevada.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 4 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Biological resources and soils	About 3.5 square kilometers (870 acres) of soil, habitat, and vegetation would be disturbed, resulting in lost productivity and animal mortality and displacement. Adverse impacts to the desert tortoise and loss of individuals would occur. Wetland assessment concluded impacts would be small. Impacts from transportation would include the loss of 0 (legal-weight truck) to 20 square kilometers (4,900 acres) (rail) of habitat in Nevada. Impacts to the desert tortoise probably would occur if a rail line were constructed. Additional wetlands assessments would be performed in the future as necessary.	Inclusive of the Proposed Action, a total of as much as 4.5 square kilometers (1,100 acres) of soil, habitat, and vegetation would be disturbed, resulting in lost productivity and animal mortality and displacement. Adverse impacts to the desert tortoise would occur. Wetland assessment concluded impacts would be small. Impacts from transportation would be the same as those under the Proposed Action. Additional wetlands assessments would be performed in the future as necessary.	No other actions were identified with potential cumulative biological resource or soil impacts within the region of influence of repository construction, operation and monitoring, and closure.	As much as 4.5 square kilometers (1,100 acres) of soil, habitat, and vegetation would be disturbed, resulting in lost productivity and animal mortality and displacement. Adverse impacts to the desert tortoise and loss of individuals would occur. Impacts to potential jurisdictional wetlands would be very small and minimized. Impacts from transportation would include the loss of 0 (legal-weight truck) to 20 square kilometers (4,900 acres) (rail) of habitat in Nevada, a portion of which would be within the Yucca Mountain vicinity. Impacts to the desert tortoise and wetlands probably would occur if a rail line were constructed. Additional wetlands assessments would be performed in the future as necessary.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 5 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Cultural resources	Repository development would disturb about 3.5 square kilometers (870 acres). Direct and indirect impacts (damage to archaeological and historical sites or illicit collection of artifacts) would be mitigated per applicable regulations. In addition, as much as 20 square kilometers (4,900 acres) would be disturbed along transportation routes in Nevada. Native Americans view all impacts to be adverse and immune to mitigation.	Land disturbance for repository development would increase to a total of as much as 4.5 square kilometers (1,100 acres). Transportation impacts would be the same as those under the Proposed Action. Direct and indirect impacts and mitigations would be similar to the Proposed Action. Native Americans view all impacts to be adverse and immune to mitigation.	No other actions were identified with potential cumulative cultural resource impacts within the region of influence of repository construction, operation and monitoring, and closure. Native Americans view all impacts to be adverse and immune to mitigation.	Repository development would disturb as much as 4.5 square kilometers (1,100 acres). As much as 20 square kilometers (4,900 acres) would be disturbed if a rail line was constructed in Nevada. Direct and indirect impacts (damage to archaeological and historical sites or illicit collection of artifacts) would be mitigated per applicable regulations. Native Americans view all impacts to be adverse and immune to mitigation.
Socioeconomics	Estimated peak direct employment of 1,800 occurring in 2006 would result in less than a 1 percent increase in direct and indirect regional employment. Employment increases would range from less than 1 percent to 5.7 percent (use of intermodal transfer station or rail line in Lincoln County, Nevada) of total employment by county.	Estimated peak employment would be the same as for the Proposed Action, but would be extended by the longer time (14 years) for emplacement and development activities. Impacts to Lincoln County would be the same as for the Proposed Action.	**Nevada Test Site:** Estimated total of approximately 4,550 direct jobs by 2005 would occur prior to construction of the repository and small cumulative impacts would be expected.	Estimated peak employment increase of about 6,350 occurring in 2005-2006 would result in less than a 4- to 9-percent increase in direct and indirect regional employment (with as much as a 5.7-percent change if intermodal transfer station or rail line were located in Lincoln County, Nevada).
Occupational and public health and safety				
Industrial hazards (nonradiological)	1 to 2 fatalities during construction, operation and monitoring, and closure. Exposures well below regulatory limits. Also, between 11 and 16 fatalities from commuting, and transportation of material.	3 or less fatalities during construction, operation and monitoring, and closure. Exposures well below regulatory limits. Also, between 11 and 16 fatalities from commuting, and transportation of material.	No other actions were identified with potential cumulative industrial hazard impacts.	13 to 19 fatalities during construction, operation and monitoring, and closure (including transportation). Exposures well below regulatory limits.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 6 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Occupational and public health and safety (continued)				
Radiological health impacts				
Workers	3 to 4 latent cancer fatalities from repository construction, operation and monitoring, and closure. Up to 3 or up to 11 latent cancer fatalities to workers from shipping material by rail and truck, respectively.	3 to 6 latent cancer fatalities from repository construction, operation and monitoring, and closure. Impacts from transportation would be similar to those from the Proposed Action.	No other actions were identified with potential cumulative radiological health impacts to repository workers.	About 6 to 17 latent cancer fatalities from repository construction, operation and monitoring, and closure (including transportation)
Public	Estimated doses would result in less than 1 latent cancer fatality to the public from repository construction, operation and monitoring, and closure. Up to 3 or up to 18 latent cancer fatalities would result from shipping material by rail and truck, respectively.	Estimated doses would result in less than one latent cancer fatality to the public from repository construction, operation and monitoring, and closure. Impacts from transportation would be similar to those from the Proposed Action.	**Nevada Test Site:** Estimated doses and associated health effects from the Nevada Test Site would be about 0.0055 latent cancer fatalities over 10 years.	About 3 to 18 latent cancer fatalities from repository construction, operation and monitoring, and closure (including transportation); and Nevada Test Site activities.
Accidents	No latent cancer fatalities would be likely from the maximum reasonably foreseeable repository accident scenarios. Between 5 and 31 latent cancer fatalities would result from a maximum reasonably foreseeable transportation accident scenario that has 1.9 chances in 10 million of occurring.	The accident risk (probability of occurrence times consequence) is essentially the same as that for the Proposed Action. Impacts of a maximum reasonably foreseeable transportation accident scenario would be the same as those for the Proposed Action.	No other actions were identified with potential cumulative accident risk impacts.	No latent cancer fatalities would be likely from the maximum reasonably foreseeable repository accident scenario. Between 5 and 31 latent cancer fatalities would result from a maximum reasonably foreseeable transportation accident scenario that has a 1.9 in 10 million potential of occurring.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 7 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Noise	Impacts from construction, operation and monitoring, and closure of a repository would result in low noise impacts. Noise levels would be transient, less than 90 dBA[c]. New intermittent noise source if a rail line was used in Nevada, including in the Yucca Mountain region.	Same as the Proposed Action.	No other actions were identified with potential cumulative noise impacts within the region of influence of repository construction, operation and monitoring, and closure.	Impacts from construction, operation and monitoring, and closure of a repository would result in low noise impacts. Noise levels would be transient, less than 90 dBA[c]. New intermittent noise source if a rail line was used in Nevada, including in the Yucca Mountain.
Aesthetics	Low. Additional structures at the repository and rail line if rail was used in Nevada. Possible conflict with visual resource management goals for Jean rail corridor.	Same as the Proposed Action.	No other actions were identified with potential cumulative aesthetic impacts within the region of influence of repository construction, operation and monitoring, and closure.	Low. Additional structures at Yucca Mountain and potential rail line in rural areas in Nevada. Possible conflict with visual resource management goals for Jean rail corridor.
Utilities, energy, materials, and site services	Peak electrical power demand would require an upgrade to the electric transmission and distribution system. No adverse impacts on energy and material supplies or to site services would be expected, including materials needed for transportation capabilities in the Yucca Mountain vicinity.	Peak electrical power demand would require upgrade to the electric transmission and distribution system. Although requirements for electricity, fossil fuels, concrete, steel, and copper would increase, no adverse impacts to energy and material supplies or to site services would be expected, including materials needed for transportation capabilities in the Yucca Mountain vicinity.	No other actions were identified with potential substantial cumulative utilities, energy, materials, and site services impacts within the region of influence of repository construction, operation and monitoring, and closure.	Peak electrical power demand would require upgrade to the electric transmission and distribution system. No adverse impacts on energy and material supplies or to site services would be expected, including materials needed for transportation capabilities in the Yucca Mountain vicinity.
Waste management	Disposal of repository-generated low-level waste would represent less than 3 percent of the reserve capacity of the Nevada Test Site. If nonradioactive, nonhazardous solid waste would be disposed of at the Nevada Test Site, existing landfills would need to be expanded.	Disposal of repository-generated low-level waste would represent less than 6 percent of the reserve capacity of the Nevada Test Site. If nonradioactive, nonhazardous solid waste would be disposed of at the Nevada Test Site, the larger quantity of this waste would require even further landfill expansion at the Nevada Test Site.	**Nevada Test Site:** The total low-level radioactive waste disposal capacity of the Nevada Test Site is sufficient and would not be exceeded by the combined actions of repository development and selection of the Nevada Test Site as a regional disposal site for DOE-complex-wide low-level radioactive and mixed wastes.	The Nevada Test Site has sufficient capacity for low-level radioactive waste from all reasonably foreseeable future actions. If nonradioactive, nonhazardous solid waste would be disposed of at the Nevada Test Site, existing landfills would need to be expanded.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 8 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Environmental justice	No disproportionately high and adverse impacts to minority or low-income populations would occur for repository or transportation activities. DOE recognizes that Native American people living in the region near Yucca Mountain have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the Proposed Action, and that implementing the Proposed Action would continue restrictions on free access to the proposed site.	No disproportionately high and adverse impacts to minority or low-income populations would occur for repository or transportation activities. DOE recognizes that Native American people living in the region near Yucca Mountain have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the Proposed Action, and that implementing the Proposed Action would continue restrictions on free access to the proposed site.	No other actions were identified with potential cumulative impacts within the region of influence of repository construction, operation and monitoring, and closure that would create environmental justice concerns. DOE recognizes that Native American people living in the region near Yucca Mountain have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the Proposed Action, and that implementing the Proposed Action would continue restrictions on free access to the proposed site.	No disproportionately high and adverse cumulative impacts to minority or low-income populations would occur for repository or transportation activities. DOE recognizes that Native American people living in the region near Yucca Mountain have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the Proposed Action, and that implementing the Proposed Action would continue restrictions on free access to the proposed site.

a. As described in Section 8.1.2.1, there would be essentially no difference in the design and operation of the repository for Inventory Module 1 or 2. Therefore, the analysis considered cumulative impacts from Inventory Module 2 to be the same as those from Inventory Module 1.

b. The 40 CFR Part 61 limit of 10 millirem per year is used as a point of reference even though this limit does not apply to releases of radon that would be the predominant contributor to the dose from the proposed Yucca Mountain Repository. The 10 millirem per year dose limit was established by EPA for a member of the public from emissions to the air from manmade sources.

c. dBA = A-weighted decibels, a common sound measurement. A-weighting accounts for the fact that the human ear responds more effectively to some pitches than to others. Higher pitches receive less weighting than lower ones.

8.2.2 AIR QUALITY

8.2.2.1 Inventory Module 1 or 2 Impacts

This section addresses potential nonradiological and radiological cumulative impacts to air quality from emplacement in a repository at Yucca Mountain of the additional quantities of spent nuclear fuel and high-level radioactive waste above those evaluated for the Proposed Action, Greater-Than-Class-C waste, and Special-Performance-Assessment-Required waste (that is, Inventory Modules 1 and 2). It compares potential nonradiological and radiological cumulative impacts to applicable regulatory limits, including the new U.S. Environmental Protection Agency National Ambient Air Quality Standard for particulate matter with a diameter of less than 2.5 micrometers. A Federal appeals court recently struck down these new standards (American Trucking v. EPA 1999, all). The EIS use these standards, among other standards that were not at issue in that case, in analyzing air quality impacts. The Environmental Protection Agency has announced that it will appeal the Court's decision. Sources of nonradiological air pollutants at the proposed repository could include fugitive dust emissions from land disturbances, excavated rock handling, and concrete batch plant operations and emissions from fossil fuel consumption.

8.2.2.1.1 *Nonradiological Air Quality*

The construction, operation and monitoring, and closure of the proposed Yucca Mountain Repository for Inventory Module 1 or 2 would result in increased releases of criteria pollutants (nitrogen dioxide, sulfur dioxide, carbon monoxide, and particulate matter) and cristobalite as described in the following sections. The types of activities producing these releases would be the same as those described for the Proposed Action (see Chapter 4, Section 4.1.2).

Construction. The repository construction phase for Inventory Module 1 or 2 (2005 to 2010) would produce the higher air concentrations of criteria pollutants and cristobalite listed in Table 8-6, but these concentrations would still be small fractions of the applicable regulatory limits.

Operation and Monitoring. Table 8-7 lists estimated air quality impacts from criteria pollutants and cristobalite for Inventory Module 1 or 2. The concentrations in this table are for the period of continuing subsurface development and emplacement activities. During the subsequent monitoring and maintenance activities these concentrations would decrease considerably. While somewhat higher than those produced under the Proposed Action, all concentrations would still be small fractions of the applicable regulatory limits for Module 1 or 2. Because the development of the emplacement drifts for Module 1 or 2 would take an additional 14 years (see Table 8-3), these releases of criteria pollutants would occur over a longer period than those from the Proposed Action. In general, the values in Table 8-7 for operation and monitoring are smaller than the values in Table 8-6 for construction because there would be more land surface disturbance during construction.

Closure. Continuing the closure of the repository for either Inventory Module 1 or 2 would produce concentrations of criteria pollutants and cristobalite higher than those estimated for the Proposed Action, but they would still be small fractions of the applicable regulatory limits (see Table 8-8). With Inventory Module 1 or 2, the amount of backfill required to close the ramps, main tunnels, and ventilation shafts would be larger than that for the Proposed Action, and the size of the excavated rock pile to reclaim would be larger. In addition, the duration of the closure period for Inventory Module 1 or 2 would increase over that of the Proposed Action from 6 to 13 years, 6 to 17 years, and 15 to 27 years for the high, intermediate, and low thermal load scenarios, respectively.

Table 8-6. Estimated construction phase (2005 to 2010) criteria pollutant and cristobalite concentrations at the public maximally exposed individual location (micrograms per cubic meter).

Pollutant	Averaging time	Regulatory limit[a]	Maximum concentration[b,c,d]			Percent of regulatory limit[d]		
			High	Intermediate	Low	High	Intermediate	Low
	Proposed Action							
Nitrogen dioxide[e]	Annual	100	0.36	0.36	0.39	0.36	0.36	0.39
Sulfur dioxide[e]	Annual	80	0.088	0.088	0.091	0.11	0.11	0.12
	24-hour	365	1.0	1.0	1.0	0.28	0.28	0.29
	3-hour	1,300	6.3	6.3	6.5	0.49	0.49	0.50
Carbon monoxide[e,f]	8-hour	10,000	3.8	3.8	4.1	0.037	0.037	0.040
	1-hour	40,000	23	23	25	0.058	0.058	0.062
PM_{10} ($PM_{2.5}$)[e,f]	Annual	50 (15)	0.66	0.70	0.65	1.3	1.4	1.3
	24-hour	150 (65)	6.1	6.4	6.0	4.0	4.3	4.0
Cristobalite	Annual[g]	10	0.021	0.026	0.011	0.21	0.26	0.11
	Inventory Module 1 or 2							
Nitrogen dioxide[e]	Annual	100	0.70	0.70	0.70	0.71	0.71	0.71
Sulfur dioxide[e]	Annual	80	0.12	0.12	0.12	0.16	0.16	0.16
	24-hour	365	1.3	1.3	1.3	0.35	0.35	0.35
	3-hour	1,300	8.2	8.2	8.2	0.63	0.63	0.63
Carbon monoxide[e]	8-hour	10,000	6.6	6.6	6.6	0.065	0.065	0.065
	1-hour	40,000	39	39	39	0.099	0.099	0.099
PM_{10} ($PM_{2.5}$)[e,f]	Annual	50 (15)	0.73	0.77	0.83	1.5	1.5	1.7
	24-hour	150 (65)	6.6	6.9	7.2	4.4	4.6	4.8
Cristobalite	Annual[g]	10	0.025	0.025	0.011	0.25	0.25	0.11

a. Regulatory limits for criteria pollutants from 40 CFR 50.4 through 50.11 and Nevada Administrative Code 445B.391 (see Chapter 3, Table 3-5).
b. Sum of highest concentrations at the accessible land withdrawal boundary, regardless of direction.
c. Source: Chapter 4, Section 4.1.2 and Appendix G, Section G.1.4.
d. Numbers are rounded to two significant figures; therefore, the percent of regulatory limit might not equal the percent calculated from the numbers listed in the table.
e. These values would increase by a small percentage should a Cask Maintenance Facility be collocated at the proposed repository.
f. Data on $PM_{2.5}$ not being collected at time of analysis. However, overall PM_{10} numbers are well below standard for both.
g. There are no regulatory limits for public exposure to cristobalite, a form of crystalline silica. An Environmental Protection Agency health assessment (EPA 1996a, all) states that the risk of silicosis is less than 1 percent for a cumulative exposure to 1,000 micrograms per cubic meter-year. Using a 70-year lifetime, an approximate annual average concentration of 10 micrograms per cubic meter was established as a benchmark for comparison.

8.2.2.1.2 *Radiological Air Quality*

Inventory Module 1 or 2 would require more subsurface excavation and a longer closure phase leading to increased radon releases compared to the Proposed Action. The increased quantity of spent nuclear fuel that repository facilities would receive and package would also result in additional releases of krypton-85 from failed spent nuclear fuel cladding but, as for the Proposed Action, naturally occurring radon-222 and its radioactive decay products would still be the dominant dose contributors.

The following paragraphs discuss the estimated radiological air quality impacts in terms of the potential radiation dose to members of the public and workers for the construction, operation and monitoring, and closure phases of Inventory Module 1 or 2. For these estimates, workers exposed through the air pathway would be noninvolved workers.

Construction. Table 8-9 lists estimated doses to members of the public and workers for the construction phase. These values resulting from radon releases during the 5-year construction phase would be similar to those for the Proposed Action because the subsurface volume excavated would be about the same.

Operation and Monitoring. The doses from krypton-85 from receipt and packaging activities during the operation and monitoring phase would be very low and would be about one one-millionth (0.000001) or less of the dose from naturally occurring radon-222 and its radioactive decay products, as discussed

Table 8-7. Estimated operation and monitoring phase (2010 to 2110) criteria pollutant and cristobalite concentrations at the public maximally exposed individual location (micrograms per cubic meter).

Pollutant	Averaging time	Regulatory limit[a]	Maximum concentration[b,c,d] High	Maximum concentration[b,c,d] Intermediate	Maximum concentration[b,c,d] Low	Percent of regulatory limit[d] High	Percent of regulatory limit[d] Intermediate	Percent of regulatory limit[d] Low
			Proposed Action[e]					
Nitrogen dioxide	Annual	100	0.45	0.45	0.82	0.46	0.46	0.83
Sulfur dioxide	Annual	80	0.14	0.14	0.16	0.18	0.18	0.23
	24-hour	365	1.8	1.8	2.1	0.50	0.50	0.57
	3-hour	1,300	11	11	13	0.87	0.87	1.0
Carbon monoxide	8-hour	10,000	4.2	4.2	7.3	0.041	0.041	0.072
	1-hour	40,000	28	28	46	0.070	0.070	0.11
PM_{10} ($PM_{2.5}$)[f]	Annual	50 (15)	0.22	0.22	0.27	0.43	0.44	0.54
	24-hour	150 (65)	3.0	3.1	3.4	2.0	2.1	2.3
Cristobalite	Annual[g]	10	0.0097	0.012	0.015	0.097	0.12	0.15
			Inventory Module 1 or 2[e]					
Nitrogen dioxide	Annual	100	0.49	0.56	0.82	0.49	0.56	0.82
Sulfur dioxide	Annual	80	0.15	0.15	0.18	0.19	0.20	0.23
	24-hour	365	1.8	1.9	2.1	0.51	0.52	0.57
	3-hour	1,300	12	12	13	0.89	0.92	1.0
Carbon monoxide	8-hour	10,000	4.5	5.2	7.2	0.044	0.051	0.070
	1-hour	40,000	30	33	45	0.074	0.084	0.11
PM_{10} ($PM_{2.5}$)[f]	Annual	50 (15)	0.23	0.24	0.27	0.46	0.48	0.55
	24-hour	150 (65)	3.2	3.2	3.5	2.1	2.1	2.3
Cristobalite	Annual[g]	10	0.013	0.014	0.017	0.13	0.14	0.17

a. Regulatory limits for criteria pollutants from 40 CFR 50.4 through 50.11, and Nevada Administrative Code 445B.391 (see Chapter 3, Table 3-5).
b. Sum of highest concentrations at accessible land withdrawal boundary, regardless of direction.
c. Source: Chapter 4, Section 4.1.2 and Appendix G, Section G.1.5.
d. Numbers are rounded to two significant figures; therefore, the percent of regulatory limit might not equal the percent calculated from the numbers listed in the table.
e. These values would increase by less than 4 percent if a Cask Maintenance Facility was located at the proposed repository.
f. Data on $PM_{2.5}$ not being collected at time of analysis. However, overall PM_{10} numbers are well below standard for both.
g. There are no regulatory limits for public exposure to cristobalite, a form of crystalline silica. An Environmental Protection Agency health assessment (EPA 1996a, all) states that the risk of silicosis is less than 1 percent for a cumulative exposure to 1,000 micrograms per cubic meter-year. Using a 70-year lifetime, an approximate annual average concentration of 10 micrograms per cubic meter was established as a benchmark for comparison.

below. The annual dose from krypton-85 would be the same as that for the Proposed Action, but would occur for 38 rather than 24 years.

Table 8-10 lists doses to individuals and populations for the operation and monitoring phase. In all cases, naturally occurring radon-222 would be the dominant contributor to the doses, which would increase based on the additional excavation required for Inventory Module 1 or 2. Average annual doses would be higher to members of the public and higher to noninvolved workers during the 38 years of development and emplacement activities when the South Portal would be open and used for exhaust ventilation. The analysis estimated collective doses for public and worker populations for the 100 years of the operation and monitoring phase, including the 38 years of development and emplacement activities and 62 years of monitoring and maintenance activities. The dose to the maximally exposed member of the public is for 38 years of operations and 32 years of monitoring (that is, a 70-year lifetime). The dose to the maximally exposed noninvolved worker is for 50 years at the South Portal during development, emplacement, and monitoring activities.

Closure. Table 8-11 lists estimated doses to populations and maximally exposed individuals during the closure phase. Radiation doses would increase over those for the Proposed Action not only because of the larger excavated volume but also the longer time required for closure (13 to 27 years) in comparison to 6 to 15 years. The annual radon emissions and doses during closure would be the same as those for

Table 8-8. Estimated closure phase[a] criteria pollutant and cristobalite concentrations at the public maximally exposed individual location (micrograms per cubic meter).

Pollutant	Averaging time	Regulatory limit[b]	Maximum concentration[c,d,e]			Percent of regulatory limit[d]		
			High	Intermediate	Low	High	Intermediate	Low
			Proposed Action					
Nitrogen dioxide[f]	Annual	100	0.080	0.13	0.12	0.080	0.13	0.12
Sulfur dioxide[f]	Annual	80	0.0076	0.013	0.011	0.0097	0.016	0.014
	24-hour	365	0.057	0.093	0.082	0.016	0.025	0.022
	3-hour	1,300	0.45	0.74	0.66	0.035	0.057	0.050
Carbon monoxide[f]	8-hour	10,000	0.67	1.1	0.98	0.0065	0.011	0.0095
	1-hour	40,000	4.1	6.6	5.9	0.010	0.017	0.015
PM_{10} ($PM_{2.5}$)[f,g]	Annual	50 (15)	0.52	0.56	0.53	1.0	1.1	1.1
	24-hour	150 (65)	6.5	6.8	6.6	4.3	4.5	4.4
Cristobalite	Annual[h]	10	0.010	0.014	0.0053	0.10	0.14	0.053
			Inventory Module 1 or 2					
Nitrogen dioxide[f]	Annual	100	0.11	0.12	0.14	0.11	0.12	0.14
Sulfur dioxide[f]	Annual	80	0.011	0.011	0.013	0.014	0.014	0.016
	24-hour	365	0.079	0.081	0.093	0.021	0.022	0.026
	3-hour	1,300	0.63	0.65	0.75	0.048	0.050	0.057
Carbon monoxide[f]	8-hour	10,000	0.94	0.97	1.1	0.0092	0.0094	0.011
	1-hour	40,000	5.7	5.8	6.7	0.014	0.015	0.017
PM_{10} ($PM_{2.5}$)[f,g]	Annual	50 (15)	0.55	0.60	0.68	1.1	1.2	1.4
	24-hour	150 (65)	6.8	7.1	7.6	4.5	4.7	5.1
Cristobalite	Annual[h]	10	0.013	0.013	0.0056	0.13	0.13	0.056

a. Duration of closure phase would be 6 years for high and intermediate thermal load scenarios and 15 years for low thermal load scenario.
b. Regulatory limits for criteria pollutants from 40 CFR 50.4 through 50.11 and Nevada Administrative Code 445B.391 (see Chapter 3, Table 3-5).
c. Sum of highest concentrations at accessible land withdrawal boundary, regardless of direction.
d. Source: Chapter 4, Section 4.1.2 and Appendix G, Section G.1.6.
e. Numbers are rounded to two significant figures; therefore, the percent of regulatory limit might not equal the percent calculated from the numbers listed in the table.
f. These values would increase by a small percentage should a cask maintenance facility be co-located at the proposed repository.
g. Data on $PM_{2.5}$ not being collected at time of analysis. However, overall PM_{10} numbers are well below standard for both.
h. There are no regulatory limits for public exposure to cristobalite, a form of crystalline silica. An Environmental Protection Agency health assessment (EPA 1996a, all) states that the risk of silicosis is less than 1 percent for a cumulative exposure to 1,000 micrograms per cubic meter-year. Using a 70-year lifetime, an approximate annual average concentration of 10 micrograms per cubic meter was established as a benchmark for comparison.

monitoring and maintenance activities because the release points would be the same and because the quantities released would depend on the excavated volume. No reduction in radon releases from backfilling the main tunnels is assumed. The collective dose to the repository worker population would vary with the packaging scenario, because labor for the closure of the surface facilities would differ among these scenarios.

Summary. Based on the analysis of radiological air quality impacts from repository construction, operation and monitoring, and closure for Inventory Module 1 or 2, the highest estimated average annual dose to the maximally exposed individual member of the public would be 2.5 millirem for the low thermal load scenario during development and emplacement activities in the operation and monitoring phase. As a point of reference, this dose would be 25 percent of the 10-millirem-per-year regulatory limit in 40 CFR Part 61, even though this limit does not apply to releases of radon that are the predominant contributor to this dose. The radiation dose is 0.7 percent of the annual 340-millirem natural background dose to individuals in Amargosa Valley. Section 8.2.7 discusses human health impacts to the public that

Table 8-9. Estimated construction phase (2005 to 2010) radon-222 radiation doses to maximally exposed individuals and populations.[a,b]

	Thermal load					
	High		Intermediate		Low	
Dose	Total	Annual average[c]	Total	Annual average	Total	Annual average
	Proposed Action					
Public						
MEI[d] (millirem)	2.1	0.43	2.5	0.49	2.5	0.49
Population[e] (person-rem)	11	2.3	13	2.6	13	2.6
Noninvolved workers (surface)						
Maximally exposed noninvolved worker[f] (millirem)	23	4.7	27	5.4	27	5.4
Worker population[g](person-rem)						
Uncanistered	9.0	1.8	10	2.0	10	2.0
Noninvolved Nevada Test Site workers						
Worker population[h] (person-rem)	0.012	0.0025	0.014	0.0028	0.014	0.0028
	Inventory Module 1 or 2					
Public						
MEI[d] (millirem)	2.4	0.48	2.4	0.48	2.4	0.48
Population[e] (person-rem)	13	2.6	13	2.6	13	2.6
Noninvolved workers (surface)						
Maximally exposed noninvolved worker[f] (millirem)	26	5.2	26	5.2	26	5.2
Worker population[g] (person-rem)	10	2.0	10	2.0	10	2.0
Noninvolved Nevada Test Site workers						
Worker population[h] (person-rem)	0.014	0.0027	0.014	0.0027	0.014	0.0027

a. Source: Chapter 4, Section 4.1.2 and Appendix G, Section G.2.
b. Totals might differ from sums due to rounding.
c. Annual average doses reflect the increasing repository volume and resulting increasing radon-222 releases during subsurface construction.
d. MEI is the maximally exposed individual of the public, 20 kilometers (12 miles) south of the repository.
e. The population includes about 28,000 individuals within about 80 kilometers (50 miles) of the repository (see Section 3.1.8).
f. Maximally exposed noninvolved worker would be in the South Portal Operations Area.
g. Values vary slightly (less than 2 percent) by packaging scenario due to differences in the number of surface workers.
h. DOE workers at the Nevada Test Site [about 6,600 workers (DOE 1996f, Volume I, page A-69) 50 kilometers (30 miles) east-southeast near Mercury, Nevada].

could result from radiation exposures during construction, operation and monitoring, and closure for Inventory Module 1 or 2.

8.2.2.2 Cumulative Impacts from Inventory Module 1 or 2 and Other Federal, Non-Federal, and Private Actions

This section addresses potential nonradiological and radiological cumulative impacts to air quality from activities at the repository for the Proposed Action or Inventory Module 1 or 2 and other Federal, non-Federal, and private actions that would coincide with repository operations and potentially affect the air quality within the geographic boundaries of repository air quality impacts.

8.2.2.2.1 *Nonradiological Air Quality*

Construction, operation and monitoring, and closure of the proposed Yucca Mountain Repository would have very small impacts on regional air quality for the Proposed Action or for Inventory Module 1 or 2. Annual average concentrations of criteria pollutants at the land withdrawal boundary would be 1 percent or less of applicable regulatory limits except for PM_{10}, which the analysis estimated would be as much as 5 percent

Table 8-10. Estimated operation and monitoring phase (2010 to 2110) total radiation doses to maximally exposed individuals and populations.[a,b]

	Thermal load					
	High		Intermediate		Low	
Dose	Total	Annual average[c]	Total	Annual average	Total	Annual average
	Proposed Action					
Public						
MEI[d] (millirem)	38	0.55	45	0.65	100	1.5
Population[e] (person-rem)	260	2.6	310	3.1	710	7.1
Noninvolved workers (surface)						
Maximally exposed noninvolved worker[f] (millirem)	82	3.4	82	3.4	82	3.4
Worker population (person-rem)						
Uncanistered	64	0.64	76	0.74	140	1.4
Disposable canister	62	0.62	74	0.73	130	1.3
Dual-purpose canister	62	0.62	74	0.73	130	1.3
Nevada Test Site noninvolved workers						
Worker population[g] (person-rem)	0.39	0.0039	0.46	0.0046	1.1	0.011
	Inventory Module 1 or 2					
Public						
MEI[h] (millirem)	68	0.97	67	0.96	170	2.4
Population[e] (person-rem)	470	4.7	460	4.6	1,200	12
Noninvolved workers (surface)						
Maximally exposed noninvolved worker[h] (millirem)	130	3.4	130	3.4	130	3.4
Worker population[i] (person-rem)	140	1.4	140	1.4	330	3.3
Nevada Test Site noninvolved workers						
Worker population[h] (person-rem)	0.67	0.0067	0.68	0.0068	1.7	0.017

a. Source: Chapter 4, Section 4.1.2 and Appendix G, Section G.2.
b. Totals might differ from sums due to rounding.
c. Annual average doses reflect radon releases from the increasing repository volume and varying ventilation flows during subsurface development.
d. MEI is the maximally exposed individual of the public, 20 kilometers (12 miles) south of the repository. Dose estimate is based on 24 years of operations and 46 years of monitoring for a total of 70 years.
e. The population includes about 28,000 individuals within about 80 kilometers (50 miles) of the repository (see Section 3.1.8).
f. Maximally exposed noninvolved worker would be in the South Portal Operations Area (from radon-222 exposure) for a 50-year working lifetime including 24 years of operations activities and 26 years of monitoring activities.
g. DOE workers at the Nevada Test Site [about 6,600 workers (DOE 1996f, Volume I, page A-69) 50 kilometers (30 miles) east-southeast near Mercury, Nevada].
h. Dose estimate is based on 38 years of operations and 12 years of monitoring for a total of 50 years.
i. Values vary slightly (less than 2 percent) by packaging scenario due to differences in the number of surface workers.

of the regulatory limit at the land withdrawal boundary. This estimate does not consider standard dust suppression activities (such as wetting), so actual concentrations probably would be much lower.

DOE has monitored particulate matter concentrations in the Yucca Mountain region since 1989; gaseous criteria pollutants were monitored from October 1991 through September 1995. Concentrations were well below applicable National Ambient Air Quality Standards (see Section 3.1.2.1). In 1990, DOE also measured ambient air quality in several Nevada Test Site areas for short-term concentrations of sulfur dioxide, carbon monoxide, and PM_{10} (DOE 1996f, Volume I, pages 4-146 and 4-148). The measurements were all lower than the applicable short-term (1-hour, 3-hour, 8-hour, and 24-hour) limits.

Table 8-11. Estimated closure phase radon-222 radiation doses to maximally exposed individuals and populations.[a,b]

	Thermal load					
	High		Intermediate		Low	
Dose	Total	Annual[c]	Total	Annual	Total	Annual
	Proposed Action					
Public						
MEI[d] (millirem)	2.6	0.43	3.1	0.5	19	1.2
Population[e] (person-rem)	13	2.1	15	2.5	93	6.2
Noninvolved workers (surface)						
Maximally exposed noninvolved worker[f] (millirem)	0.24	0.039	0.28	0.047	1.7	0.12
Worker population[g] (person-rem)						
Uncanistered	0.041	0.0068	0.049	0.0082	0.12	0.020
Disposable canister	0.029	0.0049	0.035	0.0058	0.086	0.014
Dual-purpose canister	0.032	0.0053	0.038	0.0063	0.092	0.016
Nevada Test Site noninvolved workers						
Worker population[h] (person-rem)	0.021	0.0035	0.025	0.0042	0.16	0.010
	Inventory Module 1 or 2					
Public						
MEI[d] (millirem)	10	0.78	14	0.80	58	2.1
Population[e] (person-rem)	51	3.9	68	4.0	290	11
Noninvolved workers (surface)						
Maximally exposed noninvolved worker[f] (millirem)	0.94	0.072	1.3	0.074	1.9	0.07
Worker population[g] (person-rem)						
Uncanistered	0.073	0.012	0.075	0.012	0.15	0.026
Disposable canister	0.051	0.0086	0.053	0.0088	0.11	0.018
Dual-purpose canister	0.055	0.0093	0.057	0.0094	0.12	0.019
Nevada Test Site noninvolved workers						
Worker population[h] (person-rem)	0.085	0.0065	0.11	0.0067	0.48	0.018

a. Source: Chapter 4, Section 4.1.2 and Appendix G, Section G.2.
b. Totals might differ from sums due to rounding.
c. For purposes of analysis, annual radon-222 releases remain constant over the closure phase.
d. MEI is the maximally exposed individual of the public, 20 kilometers (12 miles) south of the repository.
e. The population includes about 28,000 individuals within about 80 kilometers (50 miles) of the repository (see Section 3.1.8).
f. Maximally exposed noninvolved worker would be in the South Portal Operations Area.
g. Values vary slightly by packaging scenario due to differences in the number of surface workers.
h. DOE workers at the Nevada Test Site [about 6,600 workers (DOE 1996f, Volume I, page A-69) 50 kilometers (30 miles) east-southeast near Mercury, Nevada].

Pollutant concentrations related to Nevada Test Site activities would be well below ambient air quality standards and would not increase ambient pollutant concentrations above standards in Nye County (DOE 1996f, Volume I, page 4-146). Therefore, DOE expects the cumulative impacts from proposed repository and Nevada Test Site operations to be very small.

Repository activities would have no effect on air quality in the Las Vegas Valley air basin, which is a nonattainment area for carbon monoxide and PM_{10}, because the Las Vegas Valley air basin lies approximately 120 kilometers (75 miles) southeast of the proposed repository site.

8.2.2.2.2 *Radiological Air Quality*

Past activities at the Nevada Test Site are responsible for the seepage of radioactive gases from underground testing areas and slightly increased krypton-85 levels on Pahute Mesa in the northwest corner of the Nevada Test Site (see Figure 8-2). Some radioactivity on the site is attributable to the resuspension of soils contaminated from past above-ground nuclear weapons testing (DOE 1996f, Volume I, page 4-149). Current Nevada Test Site defense program activities have not resulted in detectable offsite levels of radioactivity. Estimated radiation doses to the public during 1997 were 0.089 millirem to the maximally exposed individual [a hypothetical resident of Springdale, Nevada, which is about 18 kilometers (11 miles) west of the Nevada Test Site (see Figure 8-2)] and 0.26 person-rem to the population within 80 kilometers (50 miles) of Nevada Test Site airborne emission sources (Bechtel 1998, page 7-1). The radiation dose estimates from repository construction, operation and monitoring, and closure (see Tables 8-9, 8-10, and 8-11) would add to these estimates assuming the exposed individuals and population were the same (they are not). Conservatively adding the 1997 maximally exposed individual dose from the Nevada Test Site to the highest estimated average annual dose to the maximally exposed individual from repository operations [hypothetical individual located 20 kilometers (12 miles) south of the repository] (2.4 millirem) results in a cumulative dose of 2.5 millirem. This is about 40 percent of the 40 CFR Part 61 limit of 10 millirem and about 0.7 percent of the annual 340 millirem natural background radiation dose to individuals in Amargosa Valley. Conservatively adding the 1997 Nevada Test Site and highest estimated annual repository population dose (12 person-rem) results in a cumulative dose of 12 person-rem. No latent cancer fatalities to the population would be expected from this cumulative exposure (see Section 8.2.7).

The only other activity identified in the 80-kilometer (50-mile)-radius region of influence that could affect radiological air quality is a low-level radioactive disposal site near Beatty, Nevada, which was officially closed on January 1, 1993. The physical work of a State-approved Stabilization and Closure Plan ended in July 1994. Custodianship of the site has been transferred to the State of Nevada. Monitoring is continuing at the site to ensure that any radioactive material releases to the air continue to be low (NSHD 1999, Section on the Bureau of Health Protection Services).

8.2.3 HYDROLOGY

8.2.3.1 Surface Water

Potential impacts to surface waters from the Proposed Action would be relatively minor and limited to the immediate vicinity of land disturbances associated with the action (see Chapter 4, Section 4.1.3.2, and the floodplain/wetlands assessment in Appendix L). Surface-water impacts of primary concern would include the following:

- Introduction and movement of contaminants
- Changes to runoff or infiltration rates
- Alterations of natural drainage

This section addresses these impact areas in a discussion of possible increases or other changes that could occur as a result of the emplacement of Inventory Module 1 or 2. To be cumulative, other Federal, non-Federal, or private action effects would have to occur in the immediate area. No currently identified actions have affected meeting this criterion.

Introduction and Movement of Contaminants

For Inventory Module 1 or 2, there would be essentially no change in the potential for soil contamination during the construction, operation and monitoring, and closure phases. There would be no change in the types of contaminants present nor would there be changes in operations that would make spills or releases more likely. Similarly, there would be no change in the threat of flooding to cause contaminant releases beyond that described for the Proposed Action.

Changes to Runoff or Infiltration Rates

Compared to the estimated area of land disturbed under the Proposed Action, Inventory Module 1 or 2 would require the disturbance of additional land for the corresponding thermal load scenario (see Table 8-4). A maximum of about 2.8 square kilometers (1.1 square miles) of land would be disturbed for Module 1 or 2 for the low thermal load scenario. This increase in disturbed land would still be a relatively small portion of the natural drainage areas and would make little difference in the amount of water that soaked into the ground or reached the intermittently flowing drainage channels. Disturbed areas not covered by structures would slowly return to conditions more similar to those of the surrounding undisturbed ground.

Alterations of Natural Drainage

No additional actions or land disturbances associated with Inventory Module 1 or 2 would involve a potential to alter noteworthy natural drainage channels in the area. The excavated rock pile and its increased size for Module 1 or 2 would be in an area that would obstruct a very small portion of overland drainage. Potential impacts to floodplains would be the same as those described for the Proposed Action (see Chapter 4, Section 4.1.3.4). The construction, operation, and maintenance of a rail line, roadways, and bridges in the Yucca Mountain vicinity could affect the 100- and 500-year floodplains of Fortymile Wash, Busted Butte Wash, Drill Hole Wash, and Midway Valley Wash at Yucca Mountain. The floodplains affected and the extent of activities in the floodplains would depend on which routes DOE selected. Appendix L contains a floodplain/wetlands assessment that describes the actions DOE could take to construct, operate, and maintain a branch rail line or highway route in the Yucca Mountain vicinity.

8.2.3.2 Groundwater

8.2.3.2.1 *Inventory Module 1 or 2 Impacts*

Potential groundwater impacts would be related to the following:

- The potential for a change in infiltration rates that could increase the amount of water in the unsaturated zone and adversely affect the performance of waste containment in the repository, or decrease the amount of recharge to the aquifer
- The potential for contaminants to migrate to the unsaturated or saturated groundwater zones during the active life of the repository
- The potential for water demands associated with the repository to deplete groundwater resources to an extent that could affect downgradient groundwater use or users

Changes to Infiltration and Aquifer Recharge. If DOE emplaced Inventory Module 1 or 2, changes related to infiltration and recharge rates would be limited to two areas: a possible increase in the size of the excavated rock pile and an extended scope for subsurface activities. The following paragraphs discuss these items.

Additional land disturbance anticipated during the operation and monitoring phase would be the continued growth of the excavated rock pile. Depending on the thermal load scenario, this could involve an additional 0.15 to 0.85 square kilometer (0.06 to 0.33 square mile) of land over that required for the

Proposed Action (see Table 8-4). Although the excavated rock pile could have different infiltration rates than undisturbed ground, it probably would not be a recharge location because of the extended depth of unconsolidated material, nor would it be likely to cause a large change in the amount of water that would otherwise reach recharge areas such as drainage channels.

Underground activities and their associated potential to contribute to the deep infiltration of water would be basically the same as those described for the Proposed Action, except emplacement drift construction would take an estimated 36 years to complete with either Inventory Module 1 or 2, compared to 22 years for the Proposed Action (see Table 8-3). As described for the Proposed Action, the quantities of water in the subsurface not removed to the surface by ventilation or pumping and thus available for infiltration would be small and primarily limited to the duration of drift development when the largest quantities of water would be used in the subsurface for dust control.

Potential for Contaminant Migration to Groundwater Zones. Neither Inventory Module 1 nor 2 would involve additional actions likely to increase the potential for contaminant releases to the environment. The only possible exception to this could be the extended period of subsurface excavation activities to accommodate the additional inventory. However, this exception would be an extension of activities with minimal potential to involve substantial contaminant releases.

Potential to Deplete Groundwater Resources. Anticipated annual water demand for Inventory Module 1 or 2 would be the same or very similar to that projected for the Proposed Action. Table 8-12 summarizes estimated annual water demands for both the Proposed Action and Inventory Module 1 or 2. The table indicates only small variations in water demand during construction, with the minor differences attributable to slight changes in the rate at which subsurface development would occur.

Projected annual water demand during emplacement and development activities of the operation and monitoring phase (as listed in Table 8-12) would be very similar under Inventory Module 1 or 2 and would actually decrease under the low thermal load scenario. However, a decrease in annual demand would be the direct result of extending the duration of drift development from 22 to 36 years. [While the total quantity of water consumed during emplacement and development activities would increase by 40 to 60 percent (depending on the thermal load) over the Proposed Action, it would be withdrawn over more years.]

Projected annual water demand during monitoring activities of the operation and monitoring phase would be the same under either the Proposed Action or Inventory Module 1 or 2. In either case, the demands listed in Table 8-12 represent the highest projected during monitoring, which would last only about 3 years during surface facility decontamination. There would be very minimal water demand during the remaining monitoring activities. The closure phase for Module 1 or 2 shows there would be a decrease in projected annual water demand in comparison to the Proposed Action. This would be due to the closure phase being longer under Module 1 or 2. That is, the annual water demand would decrease, but the total amount that would be used over the entire phase would increase.

Potential impacts to water resources under Inventory Module 1 or 2 would be very similar to those under the Proposed Action because the annual water demand would change little, and the best understanding of the groundwater resource is that it is replenished on an annual basis as gauged by the perennial yield of the groundwater basin. Under Module 1 or 2, the repository's annual water demand from the western two-thirds of the Jackass Flats basin would remain below the lowest estimated value for its perennial yield of [720,000 cubic meters (580 acre-feet)] (see Chapter 3, Table 3-11).

Table 8-12. Estimated annual water demand (acre-feet) for the Proposed Action and Inventory Module 1 or 2.[a,b]

Phase	Thermal Load		
	High	Intermediate	Low
	Proposed Action		
Construction (2005 to 2010)	150	170	170
Operation and monitoring (2010 to 2110)			
Emplacement and development activities[c]			
Uncanistered	250	260	480
Disposable canister	220	230	450
Dual-purpose canister	220	230	450
Monitoring activities (first 3 years)[d,e]			
Uncanistered	200	200	200
Disposable canister	160	160	160
Dual-purpose canister	160	160	160
Closure			
Uncanistered	80	90	90
Disposable canister	80	90	90
Dual-purpose canister	80	90	90
	Inventory Module 1 or 2		
Construction (2005 to 2010)	150	150	150
Operation and monitoring (2010 to 2110)			
Emplacement and development activities[c]			
Uncanistered	250	260	430
Disposable canister	220	230	400
Dual-purpose canister	220	230	400
Monitoring activities (first 3 years)[d,e]			
Uncanistered	200	200	200
Disposable canister	160	160	160
Dual-purpose canister	160	160	160
Closure			
Uncanistered	60	60	70
Disposable canister	60	60	70
Dual-purpose canister	60	60	70

a. Source: TRW (1999a, pages 73, 76, and 80); TRW (1999b, pages 6-3, 6-14, 6-21, 6-25, 6-26, 6-37, 6-45, 6-53, 6-61, 6-65, and 6-77).
b. To convert acre-feet to cubic meters, multiply by 1,233.49.
c. A collocated Cask Maintenance Facility would increase these values by 2 to 5 percent.
d. Values shown for monitoring activities are applicable only to the first 3 years when decontamination of surface facilities would be performed. Water demand for the 73 years that follow would be low.
e. A collocated Cask Maintenance Facility would increase these values by 5 to 7 percent.

8.2.3.2.2 *Cumulative Impacts from Inventory Module 1 or 2 and Other Federal, Non-Federal, and Private Actions*

Potential impacts to groundwater, as described in Chapter 4, Section 4.1.3.3, and in Section 8.2.3.2.1, for the Proposed Action and Inventory Module 1 or 2 would be small and limited to the immediate vicinity of land disturbances associated with the action. The exception to this would be the potential impact from water demands on groundwater resources. With this single exception, other Federal, non-Federal, or private action effects would have to occur in the same region of influence to be cumulative with those resulting from the Proposed Action or Inventory Module 1 or 2, and no currently identified actions meet this criterion.

The remainder of this discussion addresses the exception to this statement—potential impacts to groundwater resources from water demand.

The discussion of impacts to groundwater resources in Chapter 4, Section 4.1.3.3, includes ongoing water demands from Area 25 of the Nevada Test Site. Area 25 is the proposed location of the primary repository surface facilities. It is also the location of wells J-12 and J-13, which would provide water for the Proposed Action and for ongoing Nevada Test Site activities in this area. The estimated water demand for these ongoing activities is 340,000 cubic meters (280 acre-feet) a year (DOE 1998n, Table 11-2, page 11-6).

As with the Proposed Action, water demand during emplacement and development activities of the operation and monitoring phase under Inventory Module 1 or 2 combined with the baseline demands from Nevada Test Site activities would exceed the lowest perennial yield estimate under the low thermal load scenario. The combined water demands under either the high or intermediate thermal load scenario, and with any of the packaging scenarios, would be below the lowest estimates of perennial yield for the western two-thirds of Jackass Flats. None of the water demand estimates would approach the high estimate of perennial yield for the entire Jackass Flats hydrographic basin, which is 4.9 million cubic meters (4,000 acre-feet) (see Chapter 3, Table 3-11). Potential impacts to groundwater resources from this combined demand would be no different than those described in Chapter 4, Section 4.1.3.3. That is, some decline in the water level would be likely near the production wells, but not extensively over the Jackass Flats basin, and general groundwater flow patterns could shift very slightly to accommodate the withdrawals. Changes in general flow patterns probably would be too small for estimation or detection.

The Nevada Test Site EIS (DOE 1996f, pages 3-18, 3-19, and 3-34) indicates that the potential construction and operation of a Solar Enterprise Zone facility would represent the only action that would cause water withdrawals on the Test Site to exceed past levels. That EIS estimates that this demand would be greater than the highest estimates of the basin's perennial yield. Therefore, cumulative impacts from the Solar Enterprise Zone facility are likely. DOE is considering several locations for the Solar Enterprise Zone facility, one of which is Area 25. If DOE built this facility in Area 25, it would obtain water from the Jackass Flats hydrologic area, and possibly from other hydrologic areas.

Cumulative demands on the Jackass Flats hydrographic area could have long-term impacts on water availability in the downgradient aquifers beneath Amargosa Desert. The groundwaters in these areas are hydraulically linked, but the exact nature and extent of that link is still a matter of study and some speculation. However, the amount of water already being withdrawn in the Amargosa Desert [averaging about 18 million cubic meters (15,000 acre-feet) of water per year from 1995 through 1997 (see Chapter 3, Table 3-10)] is much greater than the quantities being considered for withdrawal from Jackass Flats. If water pumpage from Jackass Flats were to affect water levels in Amargosa Desert, the impacts would be small in comparison to those caused by local pumping in the Amargosa Desert.

A report from the Nye County Nuclear Waste Repository Office (Buqo 1999, pages 39 to 53) provides a perspective of potential cumulative impacts with that County as the center of interest. The Nye County report evaluates impacts to all water resources potentially available in the entire county, whereas this EIS focuses principally on impacts to the Jackass Flats groundwater basin (the source of water that DOE would use for the repository) and the groundwater system that could become contaminated thousands of years in the future. Nye County reports that the potential cumulative impacts would include additive contamination as radionuclides ultimately reached the groundwater, constraints on development of groundwater due to land withdrawal, and reduction of water available for Nye County development because of use by Federal agencies (Buqo 1999, pages 49 to 51).

8.2.4 BIOLOGICAL RESOURCES

Impacts to biological resources from Inventory Module 1 or 2 would be similar to impacts that would occur as a result of the Proposed Action evaluated in Chapter 4, Section 4.1.4. Those impacts would occur primarily as a result of site clearing, placement of material in the excavated rock pile, habitat loss, and the loss of individuals of some animal species during site clearing and from vehicle traffic.

Inventory Module 1 or 2 would require disturbing biological resources in a larger area under each thermal load scenario than would be disturbed under the Proposed Action, primarily because the excavated rock pile would be larger (Table 8-13).

Table 8-13. Area of land cover types in analyzed withdrawal area disturbed by construction and the excavated rock pile (square kilometers).[a,b,c]

	Total area		Disturbed area		
Land cover	Nevada	Withdrawal area[d]	High thermal load	Intermediate thermal load	Low thermal load[e]
			Proposed Action		
Blackbrush	9,900	140	0.02	0.02	0.36
Creosote-bursage	15,000	290	0.62	0.72	1.1
Mojave mixed scrub	5,600	120	0.8	0.86	0.03
Sagebrush	67,000	16	0	0	0
Salt desert scrub	58,000	20	0	0	0
Previously disturbed[f]	NA[g]	4	0.37	0.37	0.48
Totals	**NA**	**590**	**1.82**	**1.97**	**1.98**
			Inventory Module 1 or 2		
Blackbrush	9,900	140	0.02	0.02	0.31
Creosote-bursage	15,000	290	0.72	0.87	2.0
Mojave mixed scrub	5,600	120	0.86	0.95	0.03
Sagebrush	67,000	16	0	0	0
Salt desert scrub	58,000	20	0	0	0
Previously disturbed[f]	NA	4	0.37	0.37	0.48
Totals	**NA**	**590**	**1.97**	**2.21**	**2.83**

a. Source: Facility diagrams from TRW (1999b; Figures 6.1.7-1, 6.1.7-2, 6.2.7-1, and 6.2.7-2; pages 6-42, 6-43, 6-84, and 6-85) overlain on the land cover types map (Utah State University 1996, GAP data; TRW 1998c, page 9 as adapted) using a Geographic Information System.
b. To convert square kilometers to acres, multiply by 247.1.
c. Totals might differ from sums due to rounding.
d. A small area [0.016 square kilometer (4 acres)] of the pinyon-juniper-2 land cover type occurs in the analyzed land withdrawal area, but would not be affected.
e. As described in Chapter 2, the excavated rock pile would be in a different location for a low thermal load scenario.
f. Estimate.
g. NA = not applicable.

Repository construction and the excavated rock pile to support Inventory Module 1 or 2 would disturb about 3.5 square kilometers (870 acres) of vegetation under any of the thermal load scenarios. For the low thermal load scenario, about 2 square kilometers (500 acres) of the disturbed area would result from the excavated rock pile. Disturbances would occur in areas dominated by Mojave mixed scrub and salt desert scrub land cover types. These cover types are widespread in the withdrawal area and in Nevada. Although this disturbed area is larger than that for the Proposed Action, it still would affect vegetation on less than 1 percent of the land withdrawal area.

Releases of radioactive materials would not adversely affect biological resources. Routine releases would consist of noble gases, primarily krypton-85 and radon-222. These gases would not accumulate in the environment around Yucca Mountain and would result in low doses to plants or animals.

Overall impacts to biological resources from Inventory Module 1 or 2 would be very small. Species at the repository site are generally widespread throughout the Mojave or Great Basin Deserts and repository activities would affect a very small percentage of the available habitat in the region. Changes in the regional population of any species would be undetectable and no species would be threatened with extinction. The removal of vegetation from the small area required for Module 1 or 2 or the local loss of small numbers of individuals of some species due to site clearing and vehicle traffic would not affect regional biodiversity and ecosystem function. The loss of desert tortoise habitat and small numbers of tortoises under Module 1 or 2 would have no impact on recovery efforts for this threatened species.

Activities associated with other Federal, non-Federal, and private actions in the region should not add measurable impacts to the overall impact on biological resources. However, as stated in the Nevada Test Site EIS (DOE 1996f, page 6-16), cumulative impacts to the desert tortoises would occur throughout the region, although the intensity of the impacts would vary from location to location. The largest impact to the habitat probably would occur in the Las Vegas Valley region. The Clark County Desert Conservation Plan authorizes the taking of all tortoises on 445 square kilometers (110,000 acres) of non-Federal land in the County, and on 12 square kilometers (3,000 acres) disturbed by Nevada Department of Transportation activities in Clark and adjacent counties. The plan also authorizes several recovery units designed to optimize the survival and recovery of this threatened species. Potential land disturbance activities at the Nevada Test Site under the expanded use alternative represent a small amount of available desert tortoise habitat and will not add measurably to the loss of this species (DOE 1996f, page 6-16). As discussed in Chapter 4, Section 4.1.4, repository construction activities would involve the loss of an amount of desert tortoise habitat that would be small in comparison to its range. Yucca Mountain is at the northern end of the range of this species. DOE anticipates that small numbers of tortoises would be killed inadvertently by vehicle traffic during the repository construction, operation and monitoring, and closure phases.

8.2.5 CULTURAL RESOURCES

The only identified actions that could result in cumulative cultural resource impact in the Yucca Mountain site vicinity are Inventory Module 1 or 2. The emplacement of either module would require small additional disturbances to land in areas already surveyed during site characterization activities (see Table 8-4). Because repository construction, operation and monitoring, and closure would be Federal actions, DOE would identify and evaluate cultural resources, as required by Section 106 of the National Historic Preservation Act, and would take appropriate measures to avoid or mitigate adverse impacts to such resources. As a consequence, archaeological information gathered from artifact retrieval during land disturbance would contribute additional cultural resources information to the regional data base for understanding past human occupation and use of the land. However, there would be a potential for illicit or incidental vandalism of archaeological or historic sites and artifacts as a result of increased activities in the repository area, which would be extended for Module 1 or 2 (see Table 8-3), and this could contribute to an overall loss of regional cultural resources information.

The Native American view of resource management and preservation is holistic in its definition of cultural resources, incorporating all elements of the natural and physical environment in an interrelated context (AIWS 1998, all). The Native American perspective on cultural resources is further discussed in Chapter 3, Section 3.1.6. Potential impacts resulting from the Proposed Action described in Chapter 4, Section 4.1.5, would also apply to Inventory Module 1 or 2.

8.2.6 SOCIOECONOMICS

8.2.6.1 Inventory Modules 1 and 2 Impacts

This section addresses potential impacts associated with Inventory Module 1 or 2 on socioeconomic indicators that would be above the impacts estimated for the Proposed Action (Section 4.1.6). As described in Chapter 4, Section 4.1.6, DOE established a bounding case to examine the maximum potential workforces it would need to implement thermal load scenarios and packaging scenarios and to identify the scenario combination that would have the highest employment—low thermal load with uncanistered packaging. The analysis of Inventory Modules 1 and 2 assumes the same combination. Table 8-14 summarizes the peak direct employment levels during all phases for the Proposed Action and Module 1 or 2.

Table 8-14. Estimated peak direct employment level impacts from repository phases.

		Peak direct employment levels[a,b]	
Phase	Years	Proposed Action	Module 1 or 2
Construction	2005-2010	2,400	1,600
Operation and monitoring	2010-2110		
Development and emplacement		1,800	1,800
Monitoring and maintenance		120	120
Closure	2110-varies	520	520

a. Sources: TRW (1999a, all); TRW (1999b, all).
b. Cask Maintenance Facility-related construction, operation and monitoring, and closure activities would result in an increase to peak employment of approximately 4 percent.

Construction

DOE expects the construction phase to last from 2005 until 2010. In relation to employment, the construction phase for Inventory Module 1 or 2 would require the same peak number of workers as the Proposed Action (see Table 8-14). The impacts for Module 1 or 2 would therefore be the same as those for the Proposed Action.

Operation and Monitoring

DOE expects the operation and monitoring phase to last from 2010 until 2110. Employment levels during the continuing development of the emplacement drifts and emplacement activities and during monitoring and maintenance activities would be similar to those during the Proposed Action (see Table 8-14). Although the overall duration of the operation and monitoring phase would be 100 years, the primary difference between Inventory Module 1 or 2 and the Proposed Action is the increased duration of development and emplacement activities and the reduced duration of monitoring and maintenance activities. (Under Module 1 or 2, DOE would require an additional 14 years to complete the emplacement of the waste packages. Monitoring and maintenance would still end in 2110, which would shorten the duration of these activities by 14 years).

The annualized impacts during development and emplacement activities for Inventory Module 1 or 2 would be similar to those for the Proposed Action continued an additional 14 years. Cumulative impacts would occur primarily between 2033 (the last year of Proposed Action emplacement) and 2047 (when Module 1 or 2 emplacement would end). As with the Proposed Action, direct and indirect increases in regional employment, population, personal income, Gross Regional Product, and government expenditures for Module 1 or 2 would be small. No substantial impacts would be likely during operation and monitoring for Module 1 or 2.

Closure

DOE expects the closure phase to last from 2110 until 2125 for the Proposed Action with the low thermal load scenario. Although the staffing level for Inventory Module 1 or 2 would be the same as that for the Proposed Action (see Table 8-14), it would require more time. Closure would last 27 years for Module 1 or 2. Annualized impacts for about 520 repository workers would remain the same, carried forward for 12 more years. Cumulative impacts could occur between 2125 (the last year of Proposed Action closure) and 2137 (when Module 1 or 2 closure would be completed). However, as with the Proposed Action, because workforce demands would be considerably less than the peak during operation and monitoring, impacts to regional employment (direct and indirect), population, personal income, Gross Regional Product, and government expenditures for Module 1 or 2 probably would increase less than one-half of 1 percent. No substantial impacts would be likely during closure for Module 1 or 2.

8.2.6.2 Cumulative Impacts from Inventory Module 1 or 2 and Other Federal, Non-Federal, and Private Actions

Reasonably foreseeable future actions at the Nevada Test Site could affect the socioeconomic region of influence (Nye, Clark, and Lincoln Counties). The *Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DOE 1996f, all) presents various scenarios for Nevada Test Site actions. The Record of Decision for that EIS states that DOE would implement a combination of three alternatives: Expanded Use, No Action (continue operations at current levels) regarding mixed and low-level radioactive waste management, and Alternate Use of Withdrawn Lands regarding public education (61 *FR* 65551, December 13, 1996). Under this combination of alternatives, the Nevada Test Site could generate an increase of approximately 4,550 direct jobs, and most of these workers would be likely to live in Clark County (DOE 1996f, page 5-17). Because the Nevada Test Site jobs would be created by 2005, repository peak employment levels would occur later than the peak for Nevada Test Site employment and provide the communities affected with more time to assimilate any new residents that relocated to the region. Thus, no substantial impacts would be likely to occur.

8.2.7 OCCUPATIONAL AND PUBLIC HEALTH AND SAFETY

This section discusses the short-term health and safety impacts to workers and to members of the public (radiological only) associated with construction, operation and monitoring, and closure activities at the Yucca Mountain site for Inventory Module 1 or 2 (Sections 8.2.7.1 through 8.2.7.3). Section 8.2.7.4 provides a summary of these impacts. Appendix F contains the approach and methods used to estimate the health and safety impacts and additional detailed results for Module 1 or 2 health and safety impacts to workers.

With one exception, no other Federal, non-Federal, or private actions were identified with spatially or temporally coincident short-term impacts in the region of influence that would result in cumulative health and safety impacts with those of the proposed Yucca Mountain Repository. Estimated radioactive releases from past activities at the Nevada Test Site resulted in very small radiation doses to the public (see Section 8.2.2.2.2); even combined with estimated radiation doses from a repository at Yucca Mountain, less than 1 latent cancer fatality would be likely (Section 8.2.7.4). With the increased number of persons living and working in the region, the number of injuries and fatalities from nonrepository-related activities would increase. However, injury and mortality incidence should remain unchanged or decrease, assuming the continued enforcement of occupational and public health and safety regulations.

Regarding the health and safety impact analysis for Inventory Module 1 or 2, the radiological characteristics of the spent nuclear fuel and high-level radioactive waste would be the same as those for the Proposed Action; there just would be more material to emplace. As described in Appendix A, the radioactive inventory (and radiological properties) of the Greater-Than-Class-C waste and

Special-Performance-Assessment-Required waste is much less than that for spent nuclear fuel and high-level radioactive waste. Therefore, the subsurface emplacement of the material in Inventory Module 2 would not greatly increase radiological impacts to workers over those estimated for Module 1. For the surface facility evaluation, the number of workers would be the same for Inventory Module 1 or 2 (TRW 1999a, Section 3.3, third paragraph). Therefore, DOE did not perform separate impact analyses for Modules 1 and 2.

The primary changes in the parameters that would affect the magnitude of the worker health and safety impacts between the Proposed Action and Inventory Module 1 or 2 would be the periods required to perform the work (see Table 8-3) and the numbers of workers for the different phases. Appendix F (Table F-29) contains a detailed breakdown of the estimates for the involved and noninvolved workforce for the repository phases for Inventory Module 1 or 2 in terms of full-time equivalent worker-years.

For the public, the principal changes in parameters that would affect the magnitude of the health impact estimates would be the length of the various phases (see Table 8-3) and the rate at which air would be exhausted from the repository. The exhaust rate of the subsurface ventilation system would affect both the radon-222 concentrations to which subsurface workers would be exposed and the quantity of radon-222 released to the environment. Appendix G discusses radon-222 concentrations in the subsurface environment and release rates to the environment from the various project phases.

8.2.7.1 Construction

This section presents estimates of health and safety impacts to repository workers and members of the public for the 5-year construction phase. The values are similar to those for the Proposed Action because the length of the construction phase would be the same and activities would be similar.

Industrial Hazards

Table 8-15 lists health and safety hazards to workers common to the workplace. They are based on the health and safety loss statistics listed in Appendix F, Tables F-2 and F-3. For Inventory Module 1 or 2 these impacts would be independent of the thermal load scenarios because the number of workers would be the same for all three thermal load scenarios (see Appendix F, Table F-31).

Radiological Health Impacts

This analysis presents radiological health impacts in terms of doses and resultant latent cancer fatalities. Estimated doses were converted to estimates of latent cancer fatality using a dose-to-risk conversion factor of 0.0004 and 0.0005 latent cancer fatality per person-rem for workers and the public, respectively (see Appendix F, Section F.1.1.5).

Workers. Spent nuclear fuel and high-level radioactive waste would not be present during the construction phase. Potential radiological impacts to surface workers during this phase would be limited to those from releases of naturally occurring radon-222 and its decay products with the subsurface ventilation exhaust (these impacts are presented in Section 8.2, Table 8-9). Subsurface workers would incur exposure from radiation resulting from radionuclides in the walls of the drifts and from inhalation of radon-222 in the subsurface atmosphere. Surface worker exposure would be very small compared to those for subsurface workers. The radiological doses and health impacts for Inventory Module 1 or 2 are listed in Table 8-16. The Module 1 or 2 impacts would be independent of both thermal load and packaging scenarios because the subsurface workforce would not change.

Public. Potential radiological impacts to the public during the construction phase would be limited to those from the release of naturally occurring radon-222 with the exhaust from subsurface ventilation. For

Table 8-15. Construction phase (2005 to 2010) impacts to workers from industrial hazards.[a]

Group	Proposed Action[b]								
	High thermal load			Intermediate thermal load			Low thermal load		
	UC[c]	DISP[d]	DPC[e]	UC	DISP	DPC	UC	DISP	DPC
Involved									
Total recordable cases	290	250	240	300	250	260	300	250	260
Lost workday cases	140	120	120	140	120	120	140	120	120
Fatalities	0.14	0.11	0.12	0.14	0.12	0.12	0.14	0.12	0.12
Noninvolved									
Total recordable cases	50	41	42	50	41	42	50	41	42
Lost workday cases	24	20	21	24	20	21	24	20	21
Fatalities	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
All workers (total)[f]									
Total recordable cases	340	290	280	350	290	300	350	290	300
Lost workday cases	160	140	140	170	140	140	170	140	140
Fatalities	0.18	0.15	0.16	0.18	0.16	0.16	0.18	0.16	0.16
	Inventory Module 1 or 2[g]								
				UC	DISP	DPC			
Involved									
Total recordable cases				300	250	260			
Lost workday cases				140	120	120			
Fatalities				0.14	0.12	0.12			
Noninvolved									
Total recordable cases				50	41	42			
Lost workday cases				24	20	21			
Fatalities				0.04	0.04	0.04			
All workers (total)[f]									
Total recordable cases				350	290	300			
Lost workday cases				170	140	140			
Fatalities				0.18	0.16	0.16			

a. The analysis assumes that construction would last 44 months for surface activities and 60 months for subsurface activities.
b. Source: Chapter 4, Table 4-20.
c. UC = uncanistered packaging scenario.
d. DISP = disposable canister packaging scenario.
e. DPC = dual-purpose canister packaging scenario.
f. Totals might differ from sums due to rounding.
g. Source: Appendix F, Tables F-7 and F-33.

Inventory Module 1 or 2, the construction phase and the subsurface exhaust system ventilation rate would be essentially the same as those for the Proposed Action. Thus, radiological health impacts to the public would be the same as those for the Proposed Action, as listed in Chapter 4, Table 4-22.

8.2.7.2 Operation and Monitoring

This section presents estimates of health and safety impacts to workers and members of the public during the operation and monitoring phase. The primary differences between Inventory Module 1 or 2 and the Proposed Action would be the longer durations for development and emplacement activities and the shorter duration for monitoring and maintenance activities (see Table 8-3). Under Module 1 or 2, it would take DOE 14 more years to complete drift development (36 years total) than for the Proposed Action and 14 more years to complete emplacement (38 years total) than for the Proposed Action. Because the analysis assumed that monitoring would end 100 years after the start of emplacement (or in 2110), the duration of the monitoring period would be shortened by 14 years (a total of 62 years) for Module 1 or 2 compared to the Proposed Action.

Table 8-16. Construction phase (2005 to 2010) radiological doses and health impacts to subsurface workers.[a]

Group	High thermal load	Intermediate thermal load	Low thermal load
	Proposed Action[b]		
Involved			
MEI[c] (millirem)	770	860	860
LCF[d] probability	0.0003	0.0003	0.0003
CD[e] (person-rem)	350	420	420
LCF incidence	0.14	0.17	0.17
Noninvolved			
MEI (millirem)	580	640	640
LCF probability	0.0002	0.0003	0.0003
CD (person-rem)	70	78	78
LCF incidence	0.03	0.03	0.03
All workers (total)[f]			
CD (person-rem)	420	500	500
LCF incidence	0.17	0.20	0.20
	Inventory Module 1 or 2[g]		
Involved			
MEI (millirem)		830	
LCF probability		0.0003	
CD (person-rem)		410	
LCF incidence		0.16	
Noninvolved			
MEI (millirem)		620	
LCF probability		0.0002	
CD (person-rem)		75	
LCF incidence		0.33	
All workers (total)[f]			
CD (person-rem)		480	
LCF incidence		0.19	

a. The construction phase would last 5 years. Results are for subsurface workers.
b. Source: Chapter 4, Table 4-21.
c. MEI = dose to maximally exposed individual worker.
d. LCF = latent cancer fatality.
e. CD = collective dose.
f. Totals might differ from sums due to rounding.
g. Source: Appendix F, Table F-34.

Industrial Hazards

Table 8-17 lists health and safety impacts to workers from industrial hazards common to the workplace. These impacts would be about 40 percent greater than those calculated for the Proposed Action.

Radiological Impacts

Workers. Table 8-10 lists radiation doses to workers and the public for this phase. Table 8-18 lists radiological doses and health impacts to workers during the operation and monitoring phase for Inventory Module 1 or 2. Appendix F contains additional detail and presents the radiological impacts for surface workers, subsurface workers, and monitoring activities. Radiological impacts to workers for Module 1 or 2 would be about 40 percent greater than those for the Proposed Action. The dominant factors in dose to workers are direct exposure and inhalation.

Public. Potential radiological impacts to the public from the operation and monitoring phase would result from the release of naturally occurring radon-22 and its decay products with the subsurface exhaust

Table 8-17. Operation and monitoring phase (2010 to 2110) impacts to workers from industrial hazards.

	High thermal load			Intermediate thermal load			Low thermal load		
Group	UC[a]	DISP[b]	DPC[c]	UC	DISP	DPC	UC	DISP	DPC
	Proposed Action[d]								
Involved									
TRC[e]	1,360	1,150	1,160	1,360	1,150	1,160	1,400	1,180	1,200
LWC[f]	710	610	620	710	610	620	730	640	640
Fatalities	1.1	0.88	0.89	1.1	0.88	0.89	1.1	0.90	0.92
Noninvolved									
TRC	500	450	450	500	450	450	500	450	450
LWC	250	220	220	250	220	220	250	220	220
Fatalities	0.49	0.43	0.43	0.49	0.43	0.43	0.49	0.42	0.43
All workers (total)[g]									
TRC	1,860	1,590	1,610	1,860	1,590	1,610	1,890	1,630	1,650
LWC	950	840	840	950	840	840	950	860	870
Fatalities	1.6	1.3	1.3	1.6	1.3	1.3	1.6	1.3	1.3
	Inventory Module 1 or 2[h]								
Involved									
TRC	1,850	1,530	1,550	1,890	1,570	1,590	1,990	1,670	1,690
LWC	970	840	840	1,000	860	870	1,060	920	930
Fatalities	1.5	1.1	1.2	1.5	1.2	1.2	1.5	1.2	1.3
Noninvolved									
TRC	760	680	690	760	680	690	790	710	720
LWC	380	340	340	380	340	340	390	350	360
Fatalities	0.72	0.64	0.65	0.72	0.64	0.65	0.75	0.68	0.68
All workers (total)[g]									
TRC	2,610	2,210	2,240	2,650	2,250	2,280	2,780	2,380	2,410
LWC	1,350	1,170	1,180	1,380	1,200	1,210	1,400	1,270	1,280
Fatalities	2.2	1.8	1.8	2.2	1.8	1.8	2.3	1.9	1.9

a. UC = uncanistered packaging scenario.
b. DISP = disposable canister packaging scenario.
c. DPC = dual-purpose canister packaging scenario.
d. Source: Chapter 4, Table 4-23.
e. TRC = total recordable cases.
f. LWC = lost workday cases.
g. Totals might differ from sums due to rounding.
h. Source: Appendix F, sum of Tables F-35, F-36, and F-37.

ventilation air and from radioactive gases, principally krypton-85, that could be released from the Waste Handling Building during spent nuclear fuel handling operations.

Table 8-19 lists the total radiological doses and radiological health impacts to the public from releases to the atmosphere of krypton-85 and radon-222 during the operation and monitoring phase. Radon-222 and its decay products would be the dominant dose contributors (greater than 99 percent). Radiological health impacts would be 50 to 80 percent higher than those calculated for the Proposed Action.

8.2.7.3 Closure

This section contains estimates of health and safety impacts to workers and members of the public for the closure phase. The length of this phase would depend on the thermal load scenario (see Table 8-3).

Table 8-18. Operation and monitoring phase (2010 to 2110) radiological doses and health impacts to workers.

Group	High thermal load			Intermediate thermal load			Low thermal load		
	UC[a]	DISP[b]	DPC[c]	UC	DISP	DPC	UC	DISP	DPC
	Proposed Action[d]								
Involved									
MEI[e] (millirem)	16,240	16,240	16,240	18,940	18,940	18,940	17,610	17,610	17,610
LCF[f] probability	0.006	0.006	0.006	0.008	0.008	0.008	0.007	0.007	0.007
CD[g] (person-rem)	8,120	5,330	5,380	8,450	5,660	5,710	8,530	5,740	5,790
LCF incidence	3.2	2.1	2.2	3.4	2.3	2.3	3.4	2.3	2.3
Noninvolved									
MEI (millirem)	6,200	6,200	6,200	7,550	7,550	7,550	8,000	8,000	8,000
LCF probability	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003
CD (person-rem)	350	330	330	380	360	360	400	390	390
LCF incidence	0.14	0.13	0.13	0.15	0.14	0.14	0.16	0.15	0.15
All workers (total)[h]									
CD (person-rem)	8,470	5,660	5,710	8,830	6,020	6,070	8,930	6,130	6,180
LCF incidence	3.4	2.3	2.3	3.5	2.4	2.4	3.6	2.5	2.5
	Inventory Module 1 or 2[i]								
Involved									
MEI (millirem)	19,240	19,240	19,240	15,200	15,200	15,200	16,710	16,710	16,710
LCF probability	0.008	0.008	0.008	0.006	0.006	0.006	0.007	0.007	0.007
CD (person-rem)	11,690	7,320	7,390	11,420	7,050	7,120	12,280	7,910	7,980
LCF incidence	4.7	2.9	3.0	4.6	2.8	2.8	4.9	3.2	3.2
Noninvolved									
MEI (millirem)	7,700	7,700	7,700	5,450	5,450	5,450	7,550	7,550	7,550
LCF probability	0.003	0.003	0.003	0.002	0.002	0.002	0.003	0.003	0.003
CD (person-rem)	480	460	460	440	420	420	650	630	630
LCF incidence	0.19	0.18	0.18	0.18	0.17	0.17	0.26	0.25	0.25
All workers (total)[h]									
CD (person-rem)	12,180	7,780	7,850	11,860	7,470	7,530	12,930	8,540	8,610
LCF incidence	4.9	3.1	3.1	4.7	3.0	3.0	5.2	3.4	3.4

a. UC = uncanistered packaging scenario.
b. DISP = disposable canister packaging scenario.
c. DPC = dual-purpose canister packaging scenario.
d. Source: Chapter 4, Table 4-24.
e. MEI = dose to maximally exposed individual worker over a 50-year period. The subsurface facility workers during monitoring would incur the dose listed.
f. LCF = latent cancer fatality.
g. CD = collective dose.
h. Totals might differ from sums due to rounding.
i. Source: Sum of Appendix F, Tables F-39, F-40, F-41, and F-42.

Industrial Hazards

Table 8-20 lists health and safety impacts to workers from hazards common to the workplace. These impacts would be about 50 percent greater than those for the Proposed Action.

Radiological Impacts

Workers. Table 8-21 lists radiological doses and health impacts to workers during the closure phase. During the closure phase, the primary source of radiation exposure for surface workers would be inhalation of radon-222 released through the subsurface ventilation system. Subsurface workers would be exposed to radon-222 from inhalation of air in the drifts, to external radiation from radionuclides in the rock in the drift walls, and to external radiation emanating from the waste packages. Surface worker exposures would be much smaller than those to subsurface workers, so essentially all of the exposure and

Table 8-19. Operation and monitoring phase (2010 to 2110) radiological doses and health impacts to the public.

Dose[a]/impact	High thermal load	Intermediate thermal load	Low thermal load
	Proposed Action[b]		
Individual MEI[c] dose (millirem)	38	46	100
LCF[d] probability	1.9×10^{-5}	2.3×10^{-5}	5.1×10^{-5}
Population collective dose[e] (person-rem)	260	310	710
LCF incidence	0.13	0.15	0.35
	Inventory Module 1 or 2[f]		
Individual MEI dose (millirem)	68	67	170
LCF probability	3.4×10^{-5}	3.3×10^{-5}	8.4×10^{-5}
Population collective dose (person-rem)	470	460	1,200
LCF incidence	0.23	0.23	0.59

a. From releases of radon-222 and krypton-85 to the atmosphere.
b. Source: Chapter 4, Table 4-28.
c. MEI = the maximally exposed individual of the public, 20 kilometers (12 miles) south of the repository for 24 years of operation and 46 years of monitoring for the Proposed Action and 38 years of operation and 32 years of monitoring for Inventory Module 1 or 2, for a total of 70 years.
d. LCF = latent cancer fatality.
e. Collective dose is for population within about 80 kilometers (50 miles) of Yucca Mountain.
f. Source: Table 8-10.

Table 8-20. Closure phase impacts to workers from industrial hazards.

	High thermal load			Intermediate thermal load			Low thermal load		
Group	UC[a]	DISP[b]	DPC[c]	UC	DISP	DPC	UC	DPC	DISP
	Proposed Action[d]								
Involved									
TRC[e]	180	150	150	180	150	150	300	270	270
LWC[f]	85	71	74	85	71	74	140	130	130
Fatalities	0.08	0.07	0.07	0.08	0.07	0.07	0.14	0.13	0.13
Noninvolved									
TRC	28	23	24	28	23	24	41	36	37
LWC	14	11	12	14	11	12	20	18	18
Fatalities	0.03	0.02	0.02	0.03	0.02	0.02	0.04	0.03	0.03
All workers (total)[g]									
TRC	200	170	180	200	170	180	340	300	310
LWC	99	83	85	99	83	85	160	150	150
Fatalities	0.11	0.09	0.09	0.11	0.09	0.09	0.18	0.16	0.16
	Inventory Module 1 or 2[h]								
Involved									
TRC	270	240	250	320	300	300	460	430	440
LWC	130	120	120	160	140	140	220	210	210
Fatalities	0.13	0.12	0.11	0.15	0.14	0.14	0.22	0.20	0.21
Noninvolved									
TRC	38	33	34	44	38	40	59	53	54
LWC	19	16	17	22	19	19	29	26	27
Fatalities	0.03	0.03	0.03	0.04	0.03	0.03	0.05	0.05	0.05
All workers (total)[g]									
TRC	310	280	280	370	330	340	520	480	490
LWC	150	130	140	180	160	160	250	230	240
Fatalities	0.16	0.14	0.15	0.19	0.17	0.18	0.27	0.25	0.25

a. UC = uncanistered packaging scenario.
b. DISP = disposable canister packaging scenario.
c. DPC = dual-purpose canister packaging scenario.
d. Source: Chapter 4, Table 4-29.
e. TRC = total recordable cases.
f. LWC = lost workday cases.
g. Totals might differ from sums due to rounding.
h. Source: Sum of Appendix F, Tables F-43 and F-44.

Table 8-21. Closure phase radiological doses and health impacts to workers.

Group	High thermal load	Intermediate thermal load	Low thermal load
		Proposed Action[a]	
Involved			
MEI[b] (millirem)	2,040	2,370	5,520
LCF[c] probability	0.0008	0.0009	0.002
CD[d] (person-rem)	380	450	1,100
LCF incidence	0.15	0.18	0.44
Noninvolved			
MEI (millirem)	1,090	1,340	3,540
LCF probability	0.0004	0.0005	0.001
CD (person-rem)	48	59	160
LCF incidence	0.02	0.02	0.06
All workers (total)[e]			
CD (person-rem)	430	510	1,260
LCF incidence	0.17	0.20	0.50
		Inventory Module 1 or 2[f]	
Involved			
MEI (millirem)	5,200	5,280	9,450
LCF probability	0.002	0.002	0.004
CD (person-rem)	990	960	1,880
LCF incidence	0.40	0.38	0.75
Noninvolved			
MEI (millirem)	2,950	2,710	6,010
LCF probability	0.001	0.001	0.002
CD (person-rem)	130	120	260
LCF incidence	0.05	0.05	0.11
All workers (total)[e]			
CD (person-rem)	1,120	1,080	2,150
LCF incidence	0.45	0.43	0.86

a. Source: Chapter 4, Table 4-30.
b. MEI = dose to maximally exposed individual worker; a subsurface facilities worker could potentially incur the dose listed.
c. LCF = latent cancer fatality.
d. CD = collective dose.
e. Totals might differ from sums due to rounding.
f. Source: Full-time equivalent work years from Appendix F, Table F-21; exposure rates from radon inhalation, Table F-32, from waste package exposure, Table F-6, and from ambient exposure, Table F-5.

health impacts would be to subsurface workers. The primary source of exposure would be from inhalation of radon-222 and its decay products. Radiological impacts to workers from Inventory Module 1 or 2 would be greater than those for the Proposed Action by approximately 100 percent.

Public. Potential radiation-related health impacts to the public from closure activities would result from releases of radon-222 in the subsurface ventilation flow. Section 8.2.2.1.2 describes radiation doses to the public for this phase and they are listed in Table 8-11. Table 8-22 lists radiological dose and health impacts for the closure phase. Radiological health impacts to the public for the inventory module case would be approximately 300 to 400 percent greater than those for the Proposed Action and would be independent of the packaging scenario.

8.2.7.4 Summary

This section contains three summary tables:

- A summary of health impacts to workers from industrial hazards common to the workplace for all phases (Table 8-23)

Table 8-22. Closure phase radiological doses and health impacts to the public.

Dose[a]/impact	High thermal load	Intermediate thermal load	Low thermal load
		Proposed Action[b]	
Individual			
MEI[c] dose (millirem)	2.6	3.1	19
LCF[d] probability	1.3×10^{-6}	2.0×10^{-6}	9.4×10^{-6}
Population			
Collective dose[e] (person-rem)	13	15	93
LCF incidence	0.006	0.008	0.05
		Inventory Module 1 or 2[f]	
Individual			
MEI dose (millirem)	10	14	58
LCF probability	5.1×10^{-6}	6.8×10^{-6}	2.9×10^{-5}
Population			
Collective dose (person-rem)	51	68	290
LCF incidence	0.025	0.034	0.14

a. From releases of radon-222 and krypton-85 to the atmosphere.
b. Source: Chapter 4, Table 4-31.
c. MEI = maximally exposed individual of the public, 20 kilometers (12 miles) south of the repository for total closure period.
d. LCF = latent cancer fatality.
e. Collective dose is for population within about 80 kilometers (50 miles) of Yucca Mountain.
f. Source: Table 8-11.

- A summary of radiological doses and health impacts to workers for all phases (Table 8-24)
- A summary of radiological doses and health impacts to the public for all phases (Table 8-25)

Industrial Hazards to Workers

Table 8-23 summarizes health and safety impacts to workers from industrial hazards common to the workplace for all phases. The calculated health impacts from industrial hazards common to the workplace would be in the range of 2 to 3 fatalities for Inventory Module 1 or 2. Most of the impacts would come from surface facility operations during the operation and monitoring phase. The next biggest contributor would be from emplacement drift development during the operation and monitoring phase. These two activities would account for more than 80 percent of the health and safety impacts from industrial hazards (see Appendix F, Table F-31). Industrial safety impacts for Module 1 or 2 are about 40 percent greater than those for the Proposed Action.

Radiological Health

Workers. Table 8-24 summarizes radiological doses and health impacts to workers for the Proposed Action and Inventory Module 1 or 2. It lists these impacts as the likelihood of a latent cancer fatality for the maximally exposed individual worker over a 50-year working career, and as the number of latent cancer fatalities. The calculated values for latent cancer fatalities for repository workers during the construction, operation and monitoring, and closure phases for Module 1 or 2 are in the range of 4 to 6 fatalities for Module 1 or 2. These are higher than those for the Proposed Action (2.5 to 4 fatalities) and would be about double those from normal workplace industrial hazards (see Table 8-23).

About 50 percent of the total worker radiation dose would be from the receipt and handling of spent nuclear fuel in the surface facilities. Radiation exposure from inhalation of radon-222 and its decay products by workers in the subsurface facilities would account for about 25 percent of total worker dose, with another 10 to 15 percent of the dose coming from subsurface worker exposure to radiation emanating from the waste packages.

Public. Table 8-25 summarizes radiological doses and health impacts to the public during all phases for the Proposed Action and Inventory Module 1 or 2. The radiological doses and health impacts would

Table 8-23. Estimated impacts to workers from industrial hazards during all phases.

	High thermal load			Intermediate thermal load			Low thermal load		
Group	UC[a]	DISP[b]	DPC[c]	UC	DISP	DPC	UC	DISP	DPC
	Proposed Action[d]								
Involved									
TRC[e]	1,820	1,540	1,560	1,830	1,550	1,570	1,990	1,700	1,730
LWC[f]	930	800	810	930	810	820	1,010	890	900
Fatalities	1.3	1.1	1.1	1.3	1.1	1.1	1.4	1.2	1.2
Noninvolved									
TRC	570	510	520	570	510	520	590	520	530
LWC	280	250	260	280	250	260	290	260	260
Fatalities	0.54	0.48	0.49	0.54	0.48	0.49	0.55	0.50	0.50
All workers (total)[g]									
TRC	2,400	2,050	2,080	2,410	2,060	2,090	2,580	2,230	2,260
LWC	1,210	1,065	1,070	1,220	1,060	1,070	1,280	1,140	1,160
Fatalities	1.8	1.5	1.6	1.8	1.5	1.6	1.9	1.6	1.7
	Inventory Module 1 or 2[h]								
Involved									
TRC	2,420	2,020	2,060	2,510	2,120	2,150	2,740	2,350	2,380
LWC	1,240	1,070	1,090	1,500	1,120	1,140	1,420	1,250	1,260
Fatalities	1.7	1.4	1.4	1.8	1.4	1.5	1.9	1.6	1.6
Noninvolved									
TRC	850	750	760	850	760	770	900	800	810
LWC	420	370	380	420	380	380	450	400	400
Fatalities	0.79	0.71	0.72	0.80	0.72	0.72	0.84	0.76	0.77
All workers (total)[g]									
TRC	3,260	2,780	2,820	3,360	2,880	2,920	3,640	3,160	3,200
LWC	1,670	1,450	1,460	1,720	1,500	1,520	1,820	1,650	1,670
Fatalities	2.5	2.1	2.1	2.6	2.1	2.2	2.7	2.3	2.4

a. UC = uncanistered packaging scenario.
b. DISP = disposable canister packaging scenario.
c. DPC = dual-purpose canister packaging scenario.
d. Source: Chapter 4, Table 4-32.
e. TRC = total recordable cases.
f. LWC = lost workday cases.
g. Totals might differ from sums due to rounding.
h. Source: Sum of Tables 8-15, 8-17, and 8-20.

result from exposure of the public to naturally occurring radon-222 and decay products released from the subsurface facilities in ventilation exhaust air. The calculated likelihood for Module 1 or 2 that the maximally exposed individual would experience a latent cancer fatality is less than 0.00005. The estimated increase in the number of latent cancer fatalities is less than 1 for the exposed population within about 80 kilometers (50 miles) over the period of more than 100 years of repository activities.

For purposes of comparison, the number of latent cancer fatalities calculated for the public for the Yucca Mountain construction, operation and monitoring, and closure phases for Inventory Module 1 or 2 would be less than 0.75. The average annual age-adjusted rate for cancer deaths is 185 per 100,000 Nevada residents (ACS 1998, page 6). Assuming this mortality rate is a baseline that would remain unchanged for the estimated population of 28,000 people living within about 80 kilometers of Yucca Mountain, the expected annual cancer death rate in the population would be about 50 per year. Therefore, there would be more than 5,000 cancer deaths from other causes over the period of repository operations.

Table 8-24. Estimated radiological doses and health impacts to workers during all phases.

Group	High thermal load			Intermediate thermal load			Low thermal load		
	UC[a]	DISP[b]	DPC[c]	UC	DISP	DPC	UC	DISP	DPC
	Proposed Action[d]								
Involved									
MEI[e] (millirem)	16,240	16,240	16,240	18,940	18,940	18,940	17,610	17,610	17,610
LCF[f] probability	0.006	0.006	0.006	0.008	0.008	0.008	0.007	0.007	0.007
CD[g] (person-rem)	8,850	6,060	6,110	9,320	6,530	6,580	10,060	7,270	7,320
LCF[h] incidence	3.5	2.4	2.4	3.7	2.6	2.6	4.0	2.9	2.9
Noninvolved									
MEI (millirem)	6,200	6,200	6,200	7,550	7,550	7,550	8,000	8,000	8,000
LCF probability	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003
CD (person-rem)	460	450	450	510	500	500	640	620	620
LCF incidence	0.19	0.18	0.18	0.21	0.20	0.20	0.25	0.25	0.25
All workers (total)[i]									
CD (person-rem)	9,320	6,510	6,560	9,830	7,030	7,080	10,690	7,890	7,940
LCF incidence	3.7	2.6	2.6	3.9	2.8	2.8	4.3	3.2	3.2
	Inventory Module 1 or 2[j]								
Involved									
MEI (millirem)	19,240	19,240	19,240	15,200	15,200	15,200	16,710	16,710	16,710
LCF probability	0.008	0.008	0.008	0.006	0.006	0.006	0.007	0.007	0.007
CD (person-rem)	13,090	8,720	8,790	12,780	8,420	8,480	14,570	10,200	10,270
LCF incidence	5.2	3.5	3.5	5.1	3.4	3.4	5.8	4.1	4.1
Noninvolved									
MEI (millirem)	7,700	7,700	7,700	5,450	5,450	5,450	7,550	7,550	7,550
LCF probability	0.003	0.003	0.003	0.002	0.002	0.002	0.003	0.003	0.003
CD (person-rem)	690	660	660	640	610	610	990	970	970
LCF incidence	0.28	0.27	0.27	0.26	0.24	0.24	0.40	0.39	0.39
All workers (total)[i]									
CD (person-rem)	13,780	9,380	9,450	13,420	9,030	9,100	15,560	11,170	11,240
LCF incidence	5.5	3.8	3.8	5.4	3.6	3.6	6.2	4.5	4.5

a. UC = uncanistered packaging scenario.
b. DISP = disposable canister packaging scenario.
c. DPC = dual-purpose canister packaging scenario.
d. Source: Chapter 4, Table 4-33.
e. MEI = dose to maximally exposed individual worker over a 50-year period; subsurface facility workers during the monitoring phase would incur the listed impacts.
f. LCF = latent cancer fatality.
g. CD = collective dose.
h. LCF = latent cancer fatality incidence.
i. Totals might differ from sums due to rounding.
j. Source: Sum of Tables 8-16, 8-18, and 8-21.

Table 8-25. Estimated radiological doses and health impacts to the public during all phases.

Dose[a]/impact	High thermal load	Intermediate thermal load	Low thermal load
	Proposed Action[b]		
Individual MEI[c] dose (millirem)	38	46	100
LCF[d] probability	1.9×10^{-5}	2.3×10^{-5}	5.1×10^{-5}
Population collective dose[e] (person-rem)	280	340	810
LCF incidence	0.14	0.17	0.41
	Inventory Module 1 or 2[f]		
Individual MEI dose (millirem)	68	67	170
LCF probability	3.4×10^{-5}	3.3×10^{-5}	8.5×10^{-5}
Population collective dose (person-rem)	530	540	1,500
LCF incidence	0.27	0.27	0.74

a. From releases of radon-222 and krypton-85 to the atmosphere.
b. Source: Chapter 4, Table 4-34.
c. MEI = the maximally exposed individual of the public, 20 kilometers (12 miles) south of the repository. Over a 70-year lifetime of an individual, this maximum dose occurs during the operation and monitoring phase.
d. LCF = latent cancer fatality.
e. Collective dose is for the population within about 80 kilometers (50 miles) of Yucca Mountain over all phases [that is, over a period from 118 to 132 years for Inventory Module 1 or 2].
f. Source: Sum of Tables 8-19 and 8-22, and Chapter 4, Table 4-22.

8.2.8 ACCIDENTS

Disposal in the proposed repository of the additional spent nuclear fuel and high-level radioactive waste along with the Greater-Than-Class-C waste and Special-Performance-Assessment-Required waste in Inventory Module 1 or 2 would result in a very small increase in the estimated risk from accidents described in Chapter 4, Section 4.1.8, for the Proposed Action. The potential hazards and postulated accident scenarios identified and evaluated in Chapter 4, Section 4.1.8, would be the same as those for Module 1 or 2 because there would be no change to the basic repository design or operation. The time required for receipt, packaging, and emplacement of the additional waste would extend from 24 to 38 years, but the probability of an accident scenario (likelihood per year) would be essentially unaffected. The accident scenario consequences evaluated for the Proposed Action would bound those that could occur for Inventory Module 1 or 2 because the spent nuclear fuel and high-level radioactive waste, except the Greater-Than-Class-C waste and the Special-Performance-Assessment-Required waste, would be the same. DOE has not determined the final disposition method for Greater-Than-Class-C and Special-Performance-Assessment-Required waste but, based on the characteristics and expected packaging of these wastes (type and quantity of radionuclides; see Appendix A), the accident scenario consequences calculated in Chapter 4, Section 4.1.8 for spent nuclear fuel and high-level radioactive waste would be bounding. Therefore, substantial cumulative accident impacts would be unlikely for Inventory Module 1 or 2.

In addition, the analysis identified no other Federal, non-Federal, or private action that could affect either the occurrence probability in consequences of the accident scenarios evaluated above.

8.2.9 NOISE

The emplacement of Inventory Module 1 or 2 would have noise levels associated with the construction and operation of the repository similar to those for the Proposed Action. An increase in potential noise impacts from Module 1 or 2 would result only from the increased number of shipments to the site. The expected rate of receipt would be about the same as that for the Proposed Action; therefore, the impact would be an extended period (approximately 14 years) that shipping would continue beyond the Proposed Action.

DOE does not expect other Federal, non-Federal, or private actions in the region to add measurable noise impacts to those of the Proposed Action or Inventory Module 1 or 2.

8.2.10 AESTHETICS

There would be no impacts for Inventory Module 1 or 2 beyond those described in Chapter 4, Section 4.1.10, because the profile of the repository facility would not be visible beyond the analyzed land withdrawal area boundary. DOE does not expect other Federal, non-Federal, and private industry actions in the region to add measurable aesthetic impacts to those of the Proposed Action or Inventory Module 1 or 2.

8.2.11 UTILITIES, ENERGY, MATERIALS, AND SITE SERVICES

This section discusses potential impacts to utilities, energy, materials, and site services from the construction, operation and monitoring, and closure of the repository for Inventory Module 1 or 2. The scope of the analysis includes electricity use, fossil-fuel consumption, and consumption of construction materials. Chapter 4, Section 4.1.11, evaluates special services such as emergency medical support, fire protection, and security and law enforcement, which would not change for Module 1 or 2. The material in this section parallels Section 4.1.11, which addresses impacts from the Proposed Action. DOE has not identified any other Federal, non-Federal, or private actions that would result in cumulative impacts to utilities, energy, materials, and site services.

To determine the potential impacts of Inventory Module 1 or 2, DOE evaluated the projected uses of electricity, fuel, and construction materials for each repository phase and compared them to those for the Proposed Action. The following paragraphs describe these evaluations.

Construction

As in the Proposed Action, the major impact during the construction phase for Inventory Module 1 or 2 would be the estimated demand for electric power. The peak demand for electricity for the Proposed Action would be 24 megawatts during construction (Table 8-26). During the construction required for Module 1 or 2, the peak demand for electricity would be about the same (24 to 25 megawatts). The tunnel boring machines would account for more than half of the demand for electricity during the 5-year construction phase, but power would also be required to operate ventilation equipment and to support the construction of surface facilities. As for the Proposed Action, the existing electric transmission and distribution system at the Nevada Test Site could not support this increased demand. DOE is evaluating modifications to the site electrical system, as discussed in Chapter 4, Section 4.1.11.

Table 8-26. Peak electric power demand (megawatts).[a,b]

	Time	High thermal load			Intermediate thermal load			Low thermal load		
Phase[c]	(years)	UC[d]	DISP[e]	DPC[f]	UC	DISP	DPC	UC	DISP	DPC
		Proposed Action[g]								
Construction	*2005-2010*	*24*	*24*	*24*	*24*	*24*	*24*	*24*	*24*	*24*
Operation and monitoring	*2010-2033*	*41*	*38*	*38*	*41*	*38*	*38*	*41*	*38*	*38*
Development	2010-2032	19	19	19	19	19	19	19	19	19
Emplacement	2010-2033	22	18	19	22	18	19	22	18	19
Decontamination	2034-2037	14	10	11	14	10	11	14	10	11
Monitoring	2034-2110	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
	2034-2060	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
	2034-2310	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
Closure	*2110+6-15*	*9.2*	*8.9*	*8.9*	*9.2*	*8.9*	*8.9*	*9.2*	*8.9*	*8.9*
		Inventory Module 1 or 2[g]								
Construction	*2005-2010*	*25*	*24*	*24*	*25*	*24*	*24*	*25*	*24*	*24*
Operation and monitoring	*2010-2048*	*41*	*37*	*38*	*41*	*37*	*38*	*41*	*37*	*38*
Development	2010-2046	19	19	19	19	19	19	27	27	27
Emplacement	2010-2048	22	18	19	22	18	19	22	18	19
Decontamination	2048-2051	14	10	11	14	10	11	14	10	11
Monitoring	2048-2110	8	8	8	8	8	8	8	8	8
Closure	*2110+11-27*	*9.5*	*9.2*	*9.2*	*9.5*	*9.2*	*9.2*	*9.5*	*9.2*	*9.2*

a. Sources: TRW (1999a, Section 6); TRW (1999b, Section 6).
b. Totals might differ from sums due to rounding.
c. Approximate periods for each phase would be as follows: construction, 5 years; operation and monitoring, 100 years; closure, 6 to 15 years for the Proposed Action and 11 to 27 years for Inventory Module 1 or 2.
d. UC = uncanistered packaging scenario.
e. DISP = disposable canister packaging scenario.
f. DPC = dual-purpose canister packaging scenario.
g. The estimated electric power demand from a collocated Cask Maintenance Facility would be within the repository's capacity.

The use of electricity for Inventory Module 1 or 2 would be about 240,000 megawatt-hours during the construction phase, compared to 180,000 to 240,000 megawatt-hours for the Proposed Action (see Table 8-27). This is about 30 percent above the Proposed Action. All thermal load scenarios for Module 1 or 2 would involve the construction of main drifts longer than those for the Proposed Action.

Table 8-27. Electricity use (1,000 megawatt-hours)[a,b]

		High thermal load			Intermediate thermal load			Low thermal load		
Phase[c]	Time (years)	UC[d]	DISP[e]	DPC[f]	UC	DISP	DPC	UC	DISP	DPC
		Proposed Action[g]								
Construction	*2005-2010*	*180*	*180*	*180*	*230*	*230*	*230*	*240*	*240*	*240*
Operation and monitoring	*2010-2110*	*5,500*	*4,900*	*5,000*	*6,100*	*5,600*	*5,600*	*8,600*	*8,000*	*8,100*
Development	2010-2032	650	650	650	890	890	890	2,200	2,280	2,200
Emplacement	2010-2033	2,600	2,100	2,100	2,600	2,100	2,100	2,600	2,100	2,200
Decontamination	2034-2037	250	190	200	250	190	200	250	190	200
Monitoring	2034-2110	2,000	2,000	2,000	2,400	2,400	2,400	3,500	3,500	3,500
	2034-2060	680	680	680	810	810	810	1,200	1,200	1,200
	2034-2310	7,200	7,200	7,200	8,600	8,600	8,600	13,000	13,000	13,000
Closure	*2110+6-15*	*250*	*240*	*240*	*370*	*370*	*370*	*560*	*560*	*560*
		Inventory Module 1 or 2[g]								
Construction	*2005-2010*	*240*	*240*	*240*	*240*	*240*	*240*	*240*	*240*	*240*
Operation and monitoring	*2010-2110*	*8,400*	*7,500*	*7,600*	*9,200*	*8,400*	*8,500*	*17,000*	*16,000*	*16,000*
Development	2010-2046	1,400	1,400	1,400	1,700	1,700	1,700	6,100	6,100	6,100
Emplacement	2010-2048	4,100	3,300	3,400	4,200	3,400	3,500	4,400	3,600	3,700
Decontamination	2048-2051	250	190	200	250	190	200	250	190	200
Monitoring	2048-2110	2,600	2,600	2,600	3,100	3,100	3,100	6,200	6,200	6,200
Closure	*2110+11-27*	*480*	*470*	*480*	*620*	*620*	*620*	*1,800*	*1,700*	*1,700*

a. Sources: TRW (1999a, Section 6); TRW (1999b, Section 6).
b. Totals might differ from sums due to rounding.
c. Approximate periods for each phase would be as follows: construction, 5 years; operation and monitoring, 100 years; closure, 6 to 15 years for the Proposed Action and 11 to 27 years for Inventory Module 1 or 2.
d. UC = uncanistered packaging scenario.
e. DISP = disposable canister packaging scenario.
f. DPC = dual-purpose canister packaging scenario.
g. The additional electricity used as a result of Cask Maintenance Facility construction, operation and monitoring, and closure activities would be no greater than approximately 10 percent of that for the repository.

The use of liquid fossil fuel during the construction phase would include diesel fuel and fuel oil. The estimated liquid petroleum use would be 24 to 25 million liters (6.3 to 6.6 million gallons) compared to 7.1 to 14 million liters (1.9 to 3.7 million gallons) for the Proposed Action (see Table 8-28). The usage rate should be well within the regional supply capacity and, therefore, would not result in substantial impacts.

The primary materials needed to support construction would be concrete, steel, and copper. Concrete would be used for tunnel liners. Concrete also would be used in the construction of the surface facilities. The quantity of concrete required for the surface facilities and initial emplacement drift construction would be about 400,000 cubic meters (523,000 cubic yards). Sand and gravel needs would be met from materials excavated from the repository. The value would be about 5 to 20 percent higher than that for the Proposed Action. As much as 190,000 metric tons (210,000 tons) of steel for a variety of uses including rebar, piping, vent ducts, and track, and 100 metric tons (110 tons) of copper for electrical cable also would be required. These quantities would not be likely to affect the regional supply capacity.

Operation and Monitoring

The event that would indicate the start of the operation and monitoring phase would be the beginning of emplacement of spent nuclear fuel and high-level radioactive waste. During this phase the construction of emplacement drifts would continue in parallel with emplacement activities at about the same rate as during the construction phase. As a result, the peak electric power demand would increase to between about 37 and 41 megawatts. The peak demand of 41 megawatts would be about the same as that for the Proposed Action. As was the case for the Proposed Action, DOE would have to upgrade or revise the

Table 8-28. Fossil-fuel use (million liters).[a,b,c]

Phase[d]	Time (years)	High thermal load UC[e]	High thermal load DISP[f]	High thermal load DPC[g]	Intermediate thermal load UC	Intermediate thermal load DISP	Intermediate thermal load DPC	Low thermal load UC	Low thermal load DISP	Low thermal load DPC
					Proposed Action[h]					
Construction	*2005-2010*	*8.1*	*7.1*	*7.3*	*12*	*11*	*12*	*14*	*13*	*13*
Operation and monitoring	*2010-2110*	*290*	*240*	*240*	*290*	*250*	*250*	*360*	*310*	*310*
Development	2010-2032	19	19	19	20	20	20	83	83	83
Emplacement	2010-2033	230	180	190	230	180	190	230	180	190
Decontamination	2034-2037	33	26	27	33	26	27	33	26	27
Monitoring	2034-2110	11	11	11	15	15	15	15	15	15
	2034-2060	3.9	3.9	3.9	5.0	5.0	5.0	5.0	5.0	5.0
	2034-2310	41	41	41	53	53	53	53	53	53
Closure	*2110+6-15*	*5.1*	*4.5*	*4.6*	*9.4*	*8.8*	*8.9*	*15*	*14*	*15*
					Inventory Module 1 or 2[h]					
Construction	*2005-2010*	*25*	*24*	*24*	*25*	*24*	*24*	*25*	*24*	*24*
Operation and monitoring	*2010-2110*	*450*	*370*	*380*	*470*	*410*	*400*	*580*	*500*	*510*
Development	2010-2046	45	45	45	70	70	70	170	170	170
Emplacement	2010-2048	360	290	300	360	290	300	360	290	300
Decontamination	2048-2051	33	26	27	33	26	27	33	26	27
Monitoring	2048-2110	12	12	12	12	12	12	12	12	12
Closure	*2110+11-27*	*13*	*12*	*12*	*17*	*16*	*16*	*32*	*31*	*31*

a. Sources: TRW (1999a, Section 6); TRW (1999b, Section 6).
b. To convert liters to gallons, multiply by 0.26418.
c. Totals might differ from sums due to rounding.
d. Approximate periods for each phase would be as follows: construction, 5 years; operation and monitoring, 100 years; closure, 6 to 15 years for the Proposed Action and 11 to 27 years for Inventory Module 1 or 2.
e. UC = uncanistered packaging scenario.
f. DISP = disposable canister packaging scenario.
g. DPC = dual-purpose canister packaging scenario.
h. The additional fossil fuel used as a result of Cask Maintenance Facility construction, operation and monitoring, and closure activities would be no greater than approximately 10 percent of that for the repository.

transmission and distribution system on the Nevada Test Site to meet this demand. However, the upgrade or revision for the Proposed Action would accommodate the similar increase for Inventory Module 1 or 2.

The demand for electricity for Inventory Module 1 or 2 would be well within the regional capacity for power generation. Nevada Power Company, for example, plans to maintain a reserve capacity of about 12 percent. For the beginning of the operation and monitoring phase in 2010, Nevada Power projects a net peak load of about 6,000 megawatts and plans a reserve of about 710 megawatts (NPC 1997, Figure 4, page 9). The repository peak demand of 41 megawatts would be less than 1 percent of the Nevada Power Company planned capacity and about 7 percent of planned reserves. The repository would not affect the regional availability of electric power to any extent.

Fossil-fuel use during the operation and monitoring phase would be for onsite vehicles and for heating. It should range between 370 million and 580 million liters (98 million and 153 million gallons) during repository operations. The annual usage rates would be highest during the first half of the operation and monitoring phase (emplacement and continued construction of drifts) and would decrease substantially during the monitoring period (see Table 8-28). The projected annual usage rates of liquid fossil fuels would be higher than those for the Proposed Action but would still be within the regional supply capacity.

Additional construction materials would be required to support the continued construction of emplacement drifts for Inventory Module 1 or 2. About 3,300,000 cubic meters (4,300,000 cubic yards) of concrete would be required for the low thermal load scenario, and 910,000 cubic meters (1,200,000 cubic yards) would be required for the high thermal load scenario (see Table 8-29). The requirement for

Table 8-29. Concrete use (1,000 cubic meters).[a,b,c]

Phase[d]	Time (years)	High thermal load UC[e]	High thermal load DISP[f]	High thermal load DPC[g]	Intermediate thermal load UC	Intermediate thermal load DISP	Intermediate thermal load DPC	Low thermal load UC	Low thermal load DISP	Low thermal load DPC
					Proposed Action[h]					
Construction	*2005-2010*	*330*	*330*	*330*	*390*	*380*	*380*	*390*	*390*	*390*
Operation and monitoring	*2010-2110*	*450*	*450*	*450*	*510*	*510*	*510*	*1,800*	*1,800*	*1,800*
Development	2010-2032	420	420	420	480	480	480	1,700	1,700	1,700
Emplacement	2010-2033	27	27	27	27	27	27	27	27	27
Closure	*2110+6-15*	*2*	*2*	*2*	*2*	*2*	*2*	*4*	*4*	*4*
Totals		***780***	***780***	***780***	***900***	***890***	***890***	***2,200***	***2,200***	***2,200***
					Inventory Module 1 or 2[h]					
Construction	*2005-2010*	*400*	*400*	*400*	*400*	*400*	*400*	*400*	*400*	*400*
Operation and monitoring	*2010-2110*	*910*	*910*	*910*	*1,200*	*1,200*	*1,200*	*3,300*	*3,300*	*3,300*
Development	2010-2046	870	870	870	1,100	1,100	1,100	3,200	3,200	3,200
Emplacement	2010-2048	45	45	45	45	45	45	110	110	110
Closure	*2110+11-27*	*3*	*3*	*3*	*5*	*5*	*5*	*8*	*8*	*8*
Totals		***1,300***	***1,300***	***1,300***	***1,600***	***1,600***	***1,600***	***3,700***	***3,700***	***3,700***

a. Sources: TRW (1999a, Section 6); TRW (1999b, Section 6); TRW (1999c, pages 6-17 to 6-24).
b. To convert cubic meters to cubic yards, multiply by 1.3079.
c. Totals might differ from sums due to rounding.
d. Approximate periods for each phase would be as follows: construction, 5 years; operation and monitoring, 100 years; closure, 6 to 15 years for the Proposed Action and 11 to 24 years for Inventory Modules 1 or 2.
e. UC = uncanistered packaging scenario.
f. DISP = disposable canister packaging scenario.
g. DPC = dual-purpose canister packaging scenario.
h. The additional concrete used as a result of Cask Maintenance Facility construction, operation and monitoring, and closure activities would be no greater than approximately 10 percent of that for the repository.

steel would be between 300,000 and 1,400,000 metric tons (330,000 and 1,540,000 tons), and for copper it would be about 300 and 1,600 metric tons (330 and 1,800 tons) (see Tables 8-30 and 8-31). These quantities, while 2 or 3 times those required for the Proposed Action, would be unlikely to affect the regional supply capacity because the annual usage rate would be only about 20 to 30 percent higher than that for the Proposed Action.

Closure

The peak electric power required during the closure phase for Inventory Module 1 or 2 would be only slightly higher than that for the Proposed Action and would be less than 10 megawatts for all three thermal load scenarios. This would be much less than the peak levels predicted for the earlier phases, so impacts would be small.

Fossil-fuel use would be between 12 million and 32 million liters (3.2 million and 8.5 million gallons). A small amount of concrete and steel would be used for closure. An estimated maximum of 8,000 cubic meters (10,000 cubic yards) of concrete would be required for the low thermal load scenario and about 3,000 cubic meters (3,900 cubic yards) for the high thermal load scenario. Similarly, an estimated 3,700 metric tons (4,100 tons) of steel would be required for the low thermal load scenario and about 1,400 metric tons (1,500 tons) for the high thermal load scenario. The fossil-fuel and material quantities required for closure would not be large and would not result in substantial impacts.

Table 8-30. Steel use (1,000 metric tons).[a,b,c]

Phase[d]	Time (years)	High thermal load			Intermediate thermal load			Low thermal load		
		UC[e]	DISP[f]	DPC[g]	UC	DISP	DPC	UC	DISP	DPC
		Proposed Action[h]								
Construction	*2005-2010*	*70*	*68*	*67*	*83*	*81*	*80*	*83*	*81*	*80*
Operation and monitoring	*2010-2110*	*130*	*130*	*130*	*180*	*180*	*180*	*720*	*720*	*720*
Development	2010-2032	90	90	90	140	140	140	610	610	610
Emplacement	2010-2033	42	42	42	42	42	42	110	110	110
Closure	*2110+6-15*	*0.71*	*0.71*	*0.71*	*0.92*	*0.92*	*0.92*	*2.0*	*2.0*	*2.0*
Totals		***200***	***200***	***200***	***260***	***260***	***260***	***800***	***800***	***800***
		Inventory Module 1 or 2[h]								
Construction	*2005-2010*	*190*	*190*	*190*	*190*	*190*	*190*	*190*	*190*	*190*
Operation and monitoring	*2010-2110*	*300*	*300*	*300*	*370*	*370*	*370*	*1,400*	*1,400*	*1,400*
Development	2010-2046	230	230	230	300	300	300	1,200	1,200	1,200
Emplacement	2010-2033	70	70	70	70	70	70	180	180	180
Closure	*2110+11-27*	*1.4*	*1.4*	*1.4*	*2.1*	*2.1*	*2.1*	*3.7*	*3.7*	*3.7*
Totals		***490***	***490***	***490***	***560***	***560***	***560***	***1,600***	***1,600***	***1,600***

a. Sources: TRW (1999a, Section 6); TRW (1999b, Section 6); TRW (1999c, pages 6-17 to 6-24)
b. To convert metric tons to tons, multiply by 1.1023.
c. Totals might differ from sums due to rounding.
d. Approximate periods for each phase would be as follows: construction, 5 years; operation and monitoring, 100 years; closure, 6 to 15 years for the Proposed Action and 11 to 27 years for Inventory Modules 1 or 2.
e. UC = uncanistered packaging scenario.
f. DISP = disposable canister packaging scenario.
g. DPC = dual-purpose canister packaging scenario.
h. The additional steel used as a result of Cask Maintenance Facility construction, operation and monitoring, and closure activities would be no greater than approximately 10 percent of that for the repository.

Table 8-31. Copper use (1,000 metric tons).[a,b,c]

Phase[d]	Time (years)	High thermal load			Intermediate thermal load			Low thermal load		
		UC[e]	DISP[f]	DPC[g]	UC	DISP	DPC	UC	DISP	DPC
		Proposed Action[h]								
Construction	2005-2010	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Operation and monitoring										
Development[i]	2010-2032	0.1	0.1	0.1	0.1	0.1	0.1	0.9	0.9	0.9
Closure	2110+6-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals		***0.2***	***0.2***	***0.2***	***0.2***	***0.2***	***0.2***	***1.0***	***1.0***	***1.0***
		Inventory Module 1 or 2[h]								
Construction	2005-2010	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Operation and monitoring										
Development	2010-2046	0.3	0.3	0.3	0.3	0.3	0.3	1.6	1.6	1.6
Closure	2110+11-27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals		***0.4***	***0.4***	***0.4***	***0.4***	***0.4***	***0.4***	***1.7***	***1.7***	***1.7***

a. Sources: TRW (1999a, Section 6); TRW (1999b, Section 6).
b. To convert metric tons to tons, multiply by 1.1023.
c. Totals might differ from sums due to rounding.
d. Approximate periods for each phase would be as follows: construction, 5 years; operation and monitoring, 100 years; closure, 6 to 15 years for the Proposed Action and 11 to 27 years for Inventory Module 1 or 2.
e. UC = uncanistered packaging scenario.
f. DISP = disposable canister packaging scenario.
g. DPC = dual-purpose canister packaging scenario.
h. The additional copper used as a result of Cask Maintenance Facility construction, operation and monitoring, and closure activities would be no greater than approximately 10 percent of that for the repository.
i. Copper would not be consumed during other portions of the operation and monitoring phase.

8.2.12 MANAGEMENT OF REPOSITORY-GENERATED WASTE AND HAZARDOUS MATERIALS

8.2.12.1 Inventory Module 1 or 2 Impacts

Activities for the emplacement of Inventory Module 1 or 2 would generate waste totals beyond the quantities estimated for the Proposed Action (see Chapter 4, Section 4.1.12). The waste types and the treatment and disposal of each waste type would be the same as those described for the Proposed Action.

The quantities of most waste types for Inventory Module 1 or 2 would not change in comparison to the Proposed Action during the construction phase. Sanitary sewage and industrial wastewater would have small fluctuations in comparison to the Proposed Action (TRW 1999a, page 73; TRW 1999b, pages 6-8, 6-9, 6-48, and 6-49).

The emplacement of Inventory Module 1 or 2 would require an additional 14 years of activities, which would reduce the number of maintenance and monitoring years from 76 to 62 years. Table 8-32 lists the waste quantities generated for the Proposed Action and Inventory Modules 1 and 2 for the operation and monitoring phase.

The closure of the repository after the emplacement of the Inventory Module 1 or 2 inventory would require more time than the Proposed Action. The number of years needed for closure would also increase with the lower thermal load scenarios. (Table 8-33 lists the difference in time sequences.) The additional time would lead to an increase in waste quantities.

Sanitary and industrial solid waste, sanitary sewage, and industrial wastewater would be disposed of in facilities at the repository site. These facilities would be designed to accommodate the additional waste from Inventory Module 1 or 2. However, DOE could use existing Nevada Test Site landfills to dispose of nonrecyclable construction and demolition debris and sanitary and industrial solid waste. If Nevada Test Site landfills were used, about 290,000 cubic meters (10.2 million cubic feet) to 440,000 cubic meters (15.5 million cubic feet) would be disposed of from construction through closure (TRW 1999a, Section 6; TRW 1999b, Section 6). Disposal of the Proposed Action waste quantities would require the Nevada Test Site landfills to operate past their projected operating lives and to expand as needed (Chapter 4, Section 4.1.12.2). Disposal of the larger waste quantities under Inventory Module 1 or 2 would require the availability of additional disposal capacity in future landfill expansions.

Impacts from the treatment and disposal of hazardous waste off the site would be the same for the Proposed Action and Inventory Module 1 or 2. At present, commercial facilities are available for hazardous waste treatment and disposal, and DOE expects similar facilities to be available until the closure of the repository. The National Capacity Assessment Report (EPA 1996b, pages 32, 33, 36, 46, 47, and 50) indicates that the estimated 20-year (1993 to 2013) available capacity for incineration of solids and liquids at permitted treatment, storage, and disposal facilities in the western states is about 7 times more than the demand for these services. The estimated landfill capacity is about 50 times the demand. Given the current outlook for the capacity versus demand for hazardous waste treatment and disposal, the treatment and disposal of repository-generated hazardous waste would not present a large cumulative impact.

The Nevada Test Site has an estimated total disposal capacity of 3.15 million cubic meters (110 million cubic feet). The DOE analysis of demand for low-level radioactive waste disposal at the Nevada Test Site through 2070 projects a need for about 670,000 cubic meters (24 million cubic feet or 2.8 percent) of the total disposal capacity (DOE 1998l, page 2-23). The reserve capacity at the Nevada Test Site is about 2.5 million cubic meters (88 million cubic feet). The disposal of repository-generated waste would

Table 8-32. Estimated operation and monitoring phase (2010 to 2110) waste quantities.[a]

Waste type	High thermal load UC[b]	High thermal load DISP[c]	High thermal load DPC[d]	Intermediate thermal load UC	Intermediate thermal load DISP	Intermediate thermal load DPC	Low thermal load UC	Low thermal load DISP	Low thermal load DPC
				Proposed Action					
Low-level radioactive (cubic meters)[e]	68,000	19,000	26,000	68,000	19,000	26,000	68,000	19,000	26,000
Hazardous (cubic meters)	6,100	2,400	2,300	6,100	2,400	2,300	6,100	2,400	2,300
Sanitary and industrial solid (cubic meters)	70,000	60,000	61,000	70,000	60,000	61,000	90,000	80,000	81,000
Sanitary sewage (million liters)[f]	1,800	1,500	1,600	1,800	1,500	1,600	1,800	1,600	1,600
Industrial wastewater (million liters)	900	780	780	930	810	810	1,400	1,300	1,300
				Inventory Module 1					
Low-level radioactive (cubic meters)	110,000	37,000	42,000	110,000	37,000	42,000	110,000	37,000	42,000
Hazardous (cubic meters)	9,800	3,800	3,500	9,800	3,800	3,500	9,800	3,800	3,500
				Inventory Module 2					
Low-level radioactive (cubic meters)	130,000	41,000	46,000	130,000	41,000	46,000	130,000	41,000	46,000
Hazardous (cubic meters)	12,000	4,600	4,300	12,000	4,600	4,300	12,000	4,600	4,300
				Inventory Module 1 or 2					
Sanitary and industrial solid (cubic meters)	92,000	79,000	80,000	92,000	79,000	80,000	120,000	110,000	110,000
Sanitary sewage (million liters)	2,300	2,000	2,000	2,300	2,000	2,000	2,500	2,100	2,200
Industrial wastewater (million liters)	1,400	1,300	1,300	1,500	1,300	1,300	2,200	2,000	2,000

a. Sources: Chapter 4, Section 4.1.12; TRW (1999a, pages 78, 80, and 81); TRW (1999b, pages 6-56, 6-62, 6-67, and 6-68).
b. UC = uncanistered packaging scenario.
c. DISP = disposable canister packaging scenario.
d. DPC = dual-purpose canister packaging scenario.
e. To convert cubic meters to cubic feet, multiply by 35.314.
f. To convert liters to gallons, multiply by 0.26418.

require about 2.8 percent of the reserve capacity for the Proposed Action, about 4.7 percent for Inventory Module 1, and about 5.4 percent for Inventory Module 2.

The emplacement of Inventory Module 1 or 2 would require the same types and annual quantities of hazardous materials as the Proposed Action, as described in Chapter 4, Section 4.1.12.3. These materials would be used for the additional years associated with the emplacement of the module inventory. As with the Proposed Action, no cumulative impact would be likely from the procurement and use of hazardous materials at the repository.

8.2.12.2 Cumulative Impacts from Inventory Module 1 or 2 and Other Federal, Non-Federal, and Private Actions

A reasonably foreseeable action that could result in waste management impacts that could add to those of the Proposed Action and Inventory Module 1 or 2 would be the selection of the Nevada Test Site as a regional DOE low-level radioactive waste disposal site, as discussed in the Final Waste Management

Table 8-33. Estimated closure phase waste quantities.[a]

Waste type	High thermal load			Intermediate thermal load			Low thermal load		
	UC[b]	DISP[c]	DPC[d]	UC	DISP	DPC	UC	DISP	DPC
	Proposed Action								
Low-level radioactive (cubic meters)[e]	3,500	2,100	2,500	3,500	2,100	2,500	3,500	2,100	2,500
Hazardous (cubic meters)	630	440	480	630	440	480	630	440	480
Sanitary and industrial solid (cubic meters)	5,300	4,400	4,600	5,400	4,400	4,600	10,000	9,100	9,300
Sanitary sewage (million liters)[f]	87	83	84	87	83	84	200	200	200
Industrial wastewater (million liters)	42	42	42	42	42	42	110	110	110
Demolition debris (cubic meters)	150,000	100,000	120,000	150,000	100,000	120,000	150,000	100,000	120,000
	Inventory Module 1 or 2								
Low-level radioactive (cubic meters)	3,500	2,100	2,500	3,500	2,100	2,500	3,500	2,100	2,500
Hazardous (cubic meters)	630	440	480	630	440	480	630	440	480
Sanitary and industrial solid (cubic meters)	7,700	6,700	6,900	9,100	6,800	8,300	16,000	15,000	15,000
Sanitary sewage (million liters)	150	150	150	150	150	150	350	340	350
Industrial wastewater (million liters)	27	27	27	34	34	34	150	150	150
Demolition debris (cubic meters)	150,000	100,000	120,000	150,000	100,000	120,000	150,000	100,000	120,000

a. Sources: TRW (1999a, page 73); TRW (1999b, pages 6-79 and 6-80).
b. UC = uncanistered packaging scenario.
c. DISP = disposable canister packaging scenario.
d. DPC = dual-purpose canister packaging scenario.
e. To convert cubic meters to cubic feet, multiply by 35.314.
f. To convert liters to gallons, multiply by 0.26418.

Programmatic Environmental Impact Statement (DOE 1997b, page 7-23). The repository (under the uncanistered packaging scenario) which has the largest estimated waste quantities and the other DOE sites that would use Nevada Test Site facilities for disposal under the regional disposal concept would generate about 14,000 cubic meters (490,000 cubic feet) annually (TRW 1999a, page 76; DOE 1997b, pages 7-23 and I-38).

8.2.13 ENVIRONMENTAL JUSTICE

As discussed in Chapter 4, Section 4.1.13, the environmental justice analysis brings together the results of all resource and feature analyses to determine (1) if an activity would have substantial environmental impacts and (2) if those substantial impacts would have disproportionately high and adverse human health or environmental effects on minority or low-income populations. DOE determined that cumulative impacts from Inventory Module 1 or 2 along with those expected from other Federal, non-Federal, and private actions would not produce cumulative adverse impacts to any surrounding populations, which would include minority and low-income populations. Evaluation of subsistence lifestyles and cultural values has confirmed that these factors would not change the conclusion that the absence of high and adverse impacts for the general population means there would be no disproportionately high and adverse impacts on minority or low-income communities. No substantial impacts were identified; therefore, cumulative impacts from Inventory Module 1 or 2 and other Federal, non-Federal, and private actions would not cause environmental justice concerns.

DOE recognizes that Native American people living in areas near Yucca Mountain have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the Proposed Action, and that the implementation of the Proposed Action would continue restrictions on free access to the site. Chapter 4, Section 4.1.3.4, discusses these views and beliefs.

8.3 Cumulative Long-Term Impacts in the Proposed Yucca Mountain Repository Vicinity

This section describes results from the long-term cumulative impact analysis that DOE conducted for Inventory Modules 1 and 2 (Section 8.3.1) and for past, present, and reasonably foreseeable future actions at the Nevada Test Site, and past actions at the Beatty low-level radioactive waste site (Section 8.3.2).

8.3.1 INVENTORY MODULE 1 OR 2 IMPACTS

The long-term performance assessment of Inventory Modules 1 and 2 used the same methodology described in Chapter 5 and Appendix I for the Proposed Action to estimate potential human health impacts from radioactive and chemically toxic material releases through waterborne and airborne pathways. Section 8.3.1.1 presents the radioactive and chemically toxic material source terms for Inventory Modules 1 and 2, and Sections 8.3.1.2 and 8.3.1.3 present the results of the analysis for Inventory Modules 1 and 2, respectively.

In addition to long-term human health impacts from radioactive and chemically toxic material releases, the other potential long-term impact identified following repository closure involve biological resources. Though the surface area affected by heat rise would be larger for Inventory Module 1 or 2, the thermal load (expressed in metric tons of heavy metal per acre) would be constant, and, therefore, the ground surface temperature increase would be the same. Thus, long-term biological effects of Module 1 or 2 from heat generated by waste packages that would slightly raise ground surface temperatures would be the same as those described in Chapter 5, Section 5.8 for the Proposed Action.

8.3.1.1 Radioactive and Chemically Toxic Material Source Terms for Inventory Modules 1 and 2

For calculations of long-term performance impacts, the radioactive material inventory of individual waste packages for commercial spent nuclear fuel, high-level radioactive waste, and DOE spent nuclear fuel under Inventory Modules 1 and 2 would be identical to the radioactive material inventory under the Proposed Action for the same waste categories. Inventory Module 2 includes an additional waste category for Greater-Than-Class-C and Special-Performance-Assessment-Required wastes. This category includes a different category of waste package with its own radioactive material inventory. This waste would be emplaced in 608 “naval spent nuclear fuel long waste” packages (TRW 1999c, page 6-9), of which approximately 55 would contain waste from naval reactors and the remainder would contain waste from DOE and commercial reactors. The inventory used for each modeled waste package is an averaged radioactive material inventory of each waste category (commercial spent nuclear fuel, DOE spent nuclear fuel, high-level radioactive waste, and Greater-Than-Class-C and Special-Performance-Assessment-Required wastes). More waste packages would be used for Inventory Modules 1 and 2 than for the Proposed Action to accommodate the expanded inventories. Table 8-34 lists the number of waste packages used in long-term performance assessment calculations for the Proposed Action and Modules 1 and 2.

Table 8-34. Number of waste packages used in long-term performance assessment calculations.[a]

Inventory	Commercial SNF[b]	HLW[c]	DOE SNF	GTCC and SPAR[d]	Total
Proposed Action	7,760	1,663	2,546	0	11,969
Inventory Module 1	12,933	4,456	4,341	0	21,730
Inventory Module 2	12,933	4,456	4,341	1,642	23,372

a. The number of waste packages represented in RIP model simulations would not exactly match the number of actual waste packages. Refer to Appendix I, Section I.3 for a detailed description of waste package abstraction.
b. SNF = spent nuclear fuel.
c. HLW = high-level radioactive waste.
d. GTCC = Greater-Than-Class-C, SPAR = Special-Performance-Assessment-Required.

As listed in Table 8-34, Inventory Module 2 differs from Inventory Module 1 only by the addition of 1,642 Greater-than-Class-C and Special-Performance-Assessment-Required waste packages [the abstracted number of packages for this category of waste (1,642) differs substantially from the actual number (608), but the total radionuclide inventory is identical; the difference concerns only the number of packages modeled for waste package degradation calculations in RIP and is not expected to impact results appreciably]. Table 8-35 lists the inventory of the Greater-than-Class-C and Special-Performance-Assessment-Required waste packages under Inventory Module 2.

Table 8-35. Average radionuclide inventory (curies) per waste package for Greater-Than-Class-C and Special-Performance-Assessment-Required wastes used in performance assessment calculations under Inventory Module 2.

Isotope	Inventory
Carbon-14	38
Iodine-129	1.2×10^{-8}
Neptunium-237	5.2×10^{-8}
Protactinium-231	7.00×10^{-8}
Plutonium-239	48
Plutonium-242	4.0×10^{-6}
Selenium-79	1.0×10^{-6}
Technetium-99	2.6
Uranium-234	6.2×10^{-7}

Table 8-36 lists the total inventory of elemental uranium (that is, all isotopes of uranium) for consideration as a chemically toxic material for the Proposed Action and for Inventory Module 1 or 2. The total uranium inventory for Module 1 or 2 would be about 70 percent greater than for the Proposed Action.

Table 8-36. Total inventory (kilograms)[a] of uranium in the repository under the Proposed Action and Inventory Module 1 or 2.[b]

Inventory	Commercial SNF[c]	HLW[d]	DOE SNF	Total
Proposed Action	63,000,000	4,700,000	2,300,000	70,000,000
Inventory Module 1 or 2[e]	105,000,000	12,600,000	2,500,000	120,000,000

a. To convert kilograms to pounds, multiply by 2.2046.
b. The uranium content in high-level radioactive waste was set to the MTHM equivalent for this analysis, even though much of the uranium would have been removed during reprocessing operations.
c. SNF = spent nuclear fuel.
d. HLW = high-level radioactive waste.
e. Inventory Modules 1 and 2 would have the same total uranium inventory because Greater-Than-Class-C and Special-Performance-Assessment-Required wastes, (the only additional inventory in Module 2 over Module 1) does not contain a substantial quantity of uranium.

Table 8-37 lists the total chromium inventory for the Proposed Action and Inventory Modules 1 and 2 from waste packages. The analysis used this inventory to calculate the potential impacts to human health from chemically toxic chromium in the waste package materials and in the pressurized- and boiling-water reactor fuel assemblies. The inventory does not include the chromium content of stainless steel that would be stored with the waste in the waste packages. Further information on the chromium inventory is provided in Chapter 5 and in more detail in Appendix I.

Table 8-37. Total chromium in the Proposed Action and Inventory Modules 1 and 2 (kilograms).[a,b]

Inventory	Commercial SNF[c]	HLW[d]	DOE SNF	GTCC and SPAR[e]	Total
Proposed Action	11,000,000	2,100,000	380,000	0	14,000,000
Inventory Module 1	18,000,000	4,400,000	400,000	0	23,000,000
Inventory Module 2	18,000,000	4,400,000	400,000	730,000	24,000,000

a. To convert kilograms to pounds, multiply by 2.2046.
b. Totals might differ from sums due to rounding.
c. SNF = spent nuclear fuel.
d. HLW = high-level radioactive waste.
e. GTCC = Greater-Than-Class-C waste; SPAR = Special-Performance-Assessment-Required waste.

The only radionuclide that would have a relatively large inventory and a potential for gas transport is carbon-14. Iodine-129 can exist in a gas phase, but it is highly soluble and, therefore, would be likely to dissolve in groundwater rather than migrate as a gas. After the carbon-14 escaped from the waste package, it could flow through the fractured and porous rock in the form of carbon dioxide. About 2 percent of the carbon-14 in commercial spent nuclear fuel is in gas in the space (or gap) between the fuel and the cladding around the fuel (Oversby 1987, page 92). The gaseous inventory consists of 0.234 curie of carbon-14 per commercial spent nuclear fuel waste package. The additional carbon-14 activity associated with Inventory Module 2, in relation to Module 1, would be the core shrouds. The carbon-14 would result from neutron irradiation of the core shroud metal. The carbon-14 would be unlikely to be present as gaseous carbon dioxide that could be released to the environment (see Table 8-38).

Table 8-38. Total carbon-14 in the repository for the Proposed Action and Inventory Modules 1 and 2 (curies).[a]

Inventory	Solid[b]	Gaseous[c]	Total
Proposed Action	92,000	1,800	93,000
Inventory Module 1	150,000	3,200	160,000
Inventory Module 2	240,000	3,200	240,000

a. Totals might differ from sums due to rounding.
b. Impacts of carbon-14 in solid form are addressed as waterborne radioactive material impacts.
c. Based on 0.234 curies of carbon-14 per commercial spent nuclear fuel waste package.

8.3.1.2 Impacts for Inventory Module 1

The analysis included human-health impacts from Inventory Module 1 for radioactive materials and chemically toxic materials, as discussed in the following sections.

8.3.1.2.1 *Waterborne Radioactive Material Impacts*

The analysis used the modeling methods described for the Proposed Action in Chapter 5 (and in greater detail in Appendix I) to calculate the impacts for a maximally exposed individual and population resulting from groundwater releases of radioactive material for 10,000 years and 1 million years following repository closure for Inventory Module 1.

8.3.1.2.1.1 High Thermal Load Scenario. Table 8-39 lists the estimated impacts for a maximally exposed individual for the high thermal load scenario under the Proposed Action and Inventory Module 1. In general, the impacts from Module 1 would be higher by a factor ranging from 3 to 5 times the values calculated for this scenario under the Proposed Action. This increase is higher than the ratio of inventories between Module 1 and the Proposed Action. Reasons for the higher impacts include different

Table 8-39. Impacts for a maximally exposed individual from groundwater releases of radionuclides during 10,000 years after repository closure for the high thermal load scenario under the Proposed Action and Inventory Module 1.[a]

		Mean		95th-percentile	
Inventory	Maximally exposed individual	Peak dose rate[b] (millirem/year)	Probability of a LCF[c]	Peak dose rate[b] (millirem/year)	Probability of a LCF[c]
Proposed Action	At 5 kilometers[d]	0.32	1.1×10^{-5}	1.3	4.4×10^{-5}
	At 20 kilometers	0.22	7.6×10^{-6}	0.58	2.0×10^{-5}
	At 30 kilometers	0.12	4.2×10^{-6}	0.28	1.0×10^{-5}
	At 80 kilometers	0.03	1.1×10^{-6}	0.0029	1.0×10^{-7}
Inventory Module 1	At 5 kilometers	1.6	5.6×10^{-5}	5.5	1.9×10^{-4}
	At 20 kilometers	1.1	3.7×10^{-5}	2.4	8.2×10^{-5}
	At 30 kilometers	0.48	1.7×10^{-5}	0.77	2.7×10^{-5}
	At 80 kilometers	0.15	5.3×10^{-6}	0.012	3.7×10^{-7}

a. Based on 100 simulations of total system performance for each location, using random samples of uncertain parameters.
b. All peaks occur at or near 10,000 years, indicating that the dose rate would still be rising at the end of the simulation period.
c. LCF = latent cancer fatality; incremental lifetime (70 years) risk of contracting a fatal cancer, assuming a risk of 0.0005 latent cancer fatality per rem for members of the public (NCRP 1993a, page 31).
d. To convert kilometers to miles, multiply by 0.62137.

water percolation fluxes in different areas of the repository and the percolation flux impacts on the dissolution and transport of radionuclides. Appendix I, Section I.5.2, discusses these effects further.

Table 8-40 lists the impacts to the population during the first 10,000 years after repository closure for both the Proposed Action and Inventory Module 1 for the high thermal load scenario. The population impacts would be higher than the impacts for the Proposed Action under the same thermal load scenario. For example, the population dose in the 70-year period of maximum impacts would be about 5 times greater for Module 1 than for the Proposed Action at the 95th-percentile level and the same 70-year period. However, the 10,000-year integrated doses for the 95th-percentile level would be only about 2 times greater for Module 1 than for the Proposed Action.

Table 8-40. Population impacts from groundwater releases of radionuclides during 10,000 years after repository closure for the high thermal load scenario under the Proposed Action and Inventory Module 1.[a]

		Mean		95th-percentile	
Inventory	Case	Population dose (person-rem)	Population LCFs[b]	Population dose (person-rem)	Population LCFs[b]
Proposed Action	Peak 70-year lifetime	0.015	7.5×10^{-6}	0.035	1.8×10^{-5}
	Integrated over 10,000 years	0.37	1.8×10^{-4}	1.2	5.8×10^{-4}
Inventory Module 1	Peak 70-year lifetime	0.11	5.5×10^{-5}	0.18	9.0×10^{-5}
	Integrated over 10,000 years	2.6	1.3×10^{-3}	2.9	1.4×10^{-3}

a. Based on 100 simulations of total system performance for each location, using random samples of uncertain parameters.
b. LCF = latent cancer fatality; expected number of cancer fatalities for populations, assuming a risk of 0.0005 latent cancer fatality per rem for members of the public (NCRP 1993a, page 31).

The range of the increase in population impacts for Inventory Module 1 compared to the Proposed Action listed in Table 8-40 differs from the range of increase in impacts for a maximally exposed individual under Module 1 listed in Table 8-39. The major factor in the difference is the amount of contaminated groundwater associated with the Proposed Action and Module 1. The Proposed Action calculations use 27,000 cubic meters (22 acre-feet) annually in the flow tubes when calculating population dose (Appendix I, Section I.4.5.3). This amount of water is diluted in 19,000,000 cubic meters (15,400 acre-feet) of water for regional population use. The calculations for increased repository size under Module 1 use 36,000 cubic meters (29 acre-feet) of water annually in the flow tubes. This difference in water use

WHY ARE THE MEAN IMPACTS SOMETIMES HIGHER THAN THE 95TH-PERCENTILE IMPACTS?

The *mean* impact is the arithmetic average of the 100 impact results from simulations of total-system performance. The mean is not the same as the 50th-percentile value (the 50th-percentile value is called the *median*) if the distribution is *skewed*.

The performance results reported in this EIS are highly skewed. In this context, skewed indicates that there are a few impact estimates that are much larger than the rest of the impacts. When a large value is added to a group of small values, it dominates the calculation of the mean. The simulations reported in this EIS have mean impacts that are often above the 90th-percentile and occasionally above the 95th-percentile.

increases the population dose by about a factor of 2 for Inventory Module 1 over that calculated for the Proposed Action.

Table 8-41 lists the peak dose rate and time of peak for 1 million years after repository closure for both Inventory Module 1 and the Proposed Action for the high thermal load scenario. The impacts would follow the same pattern as those for the first 10,000 years after repository closure listed in Table 8-40, with the impacts for Module 1 ranging from 2 to 4 times greater than those for the Proposed Action.

Table 8-41. Impacts for a maximally exposed individual from groundwater releases of radionuclides for 1 million years after repository closure for the high thermal load scenario under the Proposed Action and Inventory Module 1.[a]

		Mean		95th-percentile	
Inventory	Maximally exposed individual	Peak dose rate (millirem/year)	Time of peak (years)	Peak dose rate (millirem/year)	Time of peak (years)
Proposed Action	At 5 kilometers[b]	1,400	296,000	9,100	320,000
	At 20 kilometers	260	336,000	1,400	364,000
	At 30 kilometers	150	418,000	820	416,000
	At 80 kilometers	54	818,000	190	716,000
Inventory Module 1	At 5 kilometers	5,300	792,000	39,000	698,000
	At 20 kilometers	930	336,000	5,600	804,000
	At 30 kilometers	480	392,000	1,700	752,000
	At 80 kilometers	160	328,000	610	742,000

a. Based on 100 simulations of total system performance for each location, using random samples of uncertain parameters.
b. To convert kilometers to miles, multiply by 0.62137.

Table 8-42 lists peak radionuclide and alpha particle concentrations in water at four locations for the high thermal load scenario under the Proposed Action and Inventory Module 1. The peak concentrations would be for 10,000 years after repository closure. The concentrations and drinking water doses would follow the same pattern as those for the first 10,000 years after repository closure listed in Table 8-40, with the results for Module 1 being commensurately greater than those for the Proposed Action. The gross alpha concentration represents the amount of alpha particle radioactivity (alpha particles are positively charged particles emitted by certain radioactive material, made up of two neutrons and two protons). The analysis derived the consequences at each distance from a different set of 100 simulations. Therefore, fluctuations in the relative concentration of specific nuclides could occur at different distances. The radionuclides that would contribute the most to individual dose over 10,000 years would be iodine-129, technetium-99, and carbon-14. The analysis based the annual drinking water doses listed in Table 8-42 (and below in Tables 8-46 and 8-50) on the assumption that an individual drinks an average of 2 liters (0.5 gallon) of water a day.

Table 8-42. Radionuclide concentrations (picocuries per liter) in water at four locations for 10,000 years after repository closure for the high thermal load scenario under the Proposed Action and Inventory Module 1.[a]

		Mean				95th-percentile			
Inventory	Radionuclide	5 km[b]	20 km	30 km	80 km	5 km	20 km	30 km	80 km
Proposed Action	Carbon-14	2.1	1.1	6.4×10^{-1}	1.8×10^{-3}	8.2	1.8	3.1	2.7×10^{-2}
	Iodine-129	1.3×10^{-1}	7.0×10^{-2}	4.1×10^{-2}	1.0×10^{-4}	5.7×10^{-1}	1.2×10^{-1}	2.0×10^{-1}	2.0×10^{-3}
	Neptunium-237	6.4×10^{-4}	2.3×10^{-8}	6.1×10^{-15}	5.6×10^{-24}	6.5×10^{-4}	1.3×10^{-17}	1.3×10^{-23}	4.2×10^{-24}
	Protactinium-231	2.9×10^{-12}	4.7×10^{-26}	4.7×10^{-26}	2.4×10^{-26}	2.0×10^{-24}	2.0×10^{-24}	1.3×10^{-26}	1.3×10^{-26}
	Plutonium-239	5.7×10^{-5}	5.6×10^{-9}	4.8×10^{-10}	1.3×10^{-13}	1.8×10^{-9}	2.4×10^{-11}	8.1×10^{-10}	2.1×10^{-17}
	Plutonium-242	3.5×10^{-7}	2.9×10^{-11}	3.1×10^{-12}	8.9×10^{-16}	1.0×10^{-11}	7.8×10^{-14}	4.5×10^{-12}	1.5×10^{-19}
	Selenium-79	3.8×10^{-1}	8.2×10^{-4}	2.4×10^{-6}	1.4×10^{-21}	1.7	1.4×10^{-18}	6.8×10^{-19}	3.2×10^{-21}
	Technetium-99	4.5×10^{1}	3.0×10^{1}	1.0×10^{1}	3.3×10^{-2}	3.9×10^{2}	8.4×10^{1}	1.3×10^{2}	8.3×10^{-1}
	Uranium-234	8.8×10^{-5}	9.0×10^{-10}	1.2×10^{-16}	2.9×10^{-23}	8.3×10^{-5}	4.4×10^{-23}	3.7×10^{-23}	3.7×10^{-23}
	Drinking water dose (millirem/ year)	8.1×10^{-2}	4.8×10^{-2}	2.0×10^{-2}	5.9×10^{-5}	5.4×10^{-1}	1.2×10^{-1}	1.8×10^{-1}	1.3×10^{-3}
	Gross alpha	7.0×10^{-4}	2.9×10^{-8}	4.8×10^{-10}	1.3×10^{-13}	6.5×10^{-4}	2.4×10^{-11}	8.1×10^{-10}	2.1×10^{-17}
Inventory Module 1	Carbon-14	1.0×10^{1}	6.3	2.5	3.9×10^{-1}	2.9×10^{1}	6.9×10^{1}	3.2	1.3×10^{-1}
	Iodine-129	7.2×10^{-1}	4.4×10^{-1}	1.6×10^{-1}	2.8×10^{-2}	1.8	4.9	2.4×10^{-1}	8.9×10^{-3}
	Neptunium-237	1.8×10^{-3}	1.8×10^{-7}	4.8×10^{-14}	7.6×10^{-23}	1.9×10^{-3}	2.5×10^{-24}	1.3×10^{-21}	4.2×10^{-24}
	Protactinium-231	1.8×10^{-13}	5.9×10^{-26}	5.9×10^{-26}	6.0×10^{-26}	2.6×10^{-24}	7.7×10^{-27}	2.5×10^{-24}	1.3×10^{-26}
	Plutonium-239	3.9×10^{-4}	1.7×10^{-7}	1.2×10^{-9}	2.4×10^{-12}	3.2×10^{-10}	3.0×10^{-11}	4.0×10^{-11}	2.8×10^{-16}
	Plutonium-242	2.4×10^{-6}	1.1×10^{-9}	7.2×10^{-12}	1.5×10^{-14}	8.8×10^{-13}	1.7×10^{-13}	8.8×10^{-14}	1.7×10^{-18}
	Selenium-79	1.6	6.5×10^{-3}	2.3×10^{-5}	6.9×10^{-21}	3.2	3.0×10^{-20}	2.1×10^{-18}	1.2×10^{-19}
	Technetium-99	2.0×10^{2}	1.3×10^{2}	5.4×10^{1}	1.7×10^{1}	1.3×10^{3}	4.6×10^{2}	1.8×10^{2}	1.5
	Uranium-234	1.8×10^{-4}	2.5×10^{-9}	4.7×10^{-16}	8.3×10^{-23}	4.3×10^{-4}	2.2×10^{-23}	5.7×10^{-23}	3.7×10^{-23}
	Drinking water dose (millirem/year)	3.9×10^{-1}	2.4×10^{-1}	9.3×10^{-2}	2.4×10^{-2}	1.8	1.6	2.5×10^{-1}	3.6×10^{-3}
	Gross alpha	2.2×10^{-3}	3.5×10^{-7}	1.2×10^{-9}	2.4×10^{-12}	1.9×10^{-3}	3.1×10^{-11}	4.0×10^{-11}	2.8×10^{-16}

a. The concentrations for the mean and 95th-percentile consequences are the concentrations that yielded the mean and 95th-percentile doses.
b. To convert kilometers (km) to miles, multiply by 0.62137.

8.3.1.2.1.2 Intermediate Thermal Load Scenario. Table 8-43 lists the estimated impacts to a maximally exposed individual from groundwater releases of radionuclides during the first 10,000 years after repository closure for the intermediate thermal load scenario under the Proposed Action and Inventory Module 1. The impacts for Module 1 would generally be a factor ranging from 2 to 11 higher than those calculated for the Proposed Action. The increase is higher than the ratio of inventories between Module 1 and the Proposed Action. Reasons for the higher impacts include different water percolation fluxes in different regions of the repository and the percolation flux impacts on the dissolution and transport of radionuclides. Appendix I, Section I.5.2, discusses these effects further.

Table 8-44 lists population impacts from groundwater releases of radionuclides during the first 10,000 years after repository closure for the intermediate thermal load scenario under the Proposed Action and Inventory Module 1. The population impacts for Inventory Module 1 would be higher than those for the Proposed Action under the same thermal load scenario. For example, the population dose in the 70-year period of maximum impacts would be about 5 times greater for Module 1 than for the Proposed Action at the 95th-percentile level. In addition, the 10,000-year integrated dose for the 95th-percentile level would be about 4 times greater for Module 1 than for the Proposed Action. Again, as for the high thermal load scenario, the range of increase in population dose differs from the range of increase for the maximally exposed individual dose because of the difference in the amount of contaminated groundwater (see Section 8.3.1.2.1.1).

Table 8-43. Impacts for a maximally exposed individual from groundwater releases of radionuclides during the 10,000 years after repository closure for the intermediate thermal load scenario under the Proposed Action and Inventory Module 1.[a]

Inventory	Maximally exposed individual	Mean: Peak dose rate[b] (millirem/year)	Mean: Probability of a LCF[c]	95th-percentile: Peak dose rate[b] (millirem/year)	95th-percentile: Probability of a LCF[c]
Proposed Action	At 5 kilometers[d]	0.14	4.9×10^{-6}	1.1	3.9×10^{-5}
	At 20 kilometers	0.13	4.5×10^{-6}	0.58	2.0×10^{-5}
	At 30 kilometers	0.046	1.6×10^{-6}	0.11	3.9×10^{-6}
	At 80 kilometers	0.0029	1.0×10^{-7}	0.0019	6.6×10^{-8}
Inventory Module 1	At 5 kilometers	0.74	2.6×10^{-5}	3.4	1.2×10^{-4}
	At 20 kilometers	0.44	1.6×10^{-5}	1.5	5.1×10^{-5}
	At 30 kilometers	0.19	6.5×10^{-6}	0.34	1.2×10^{-5}
	At 80 kilometers	0.03	1.1×10^{-6}	0.0034	1.2×10^{-7}

a. Based on 100 simulations of total system performance for each location, using random samples of uncertain parameters.
b. All peaks occur at or near 10,000 years, indicating that the dose rate would still be rising at the end of the simulation period.
c. LCF = latent cancer fatality; incremental lifetime (70 years) risk of contracting a fatal cancer for individuals, assuming a risk of 0.0005 latent cancer fatality per rem for members of the public (NCRP 1993a, page 31).
d. To convert kilometers to miles, multiply by 0.62137.

Table 8-44. Population impacts from groundwater releases of radionuclides during the 10,000 years after repository closure for the intermediate thermal load scenario under the Proposed Action and Inventory Module 1.[a]

Inventory	Case	Mean: Population dose (person-rem)	Mean: Population LCFs[b]	95th-percentile: Population dose (person-rem)	95th-percentile: Population LCFs[b]
Proposed Action	Peak 70-year lifetime	0.007	3.3×10^{-6}	0.017	8.3×10^{-6}
	Integrated over 10,000 years	0.13	6.7×10^{-5}	0.36	1.8×10^{-4}
Inventory Module 1	Peak 70-year lifetime	0.043	2.2×10^{-5}	0.080	4.0×10^{-5}
	Integrated over 10,000 years	1.0	5.2×10^{-4}	1.4	7.2×10^{-4}

a. Based on 100 simulations of total system performance for each location, using random samples of uncertain parameters.
b. LCF = latent cancer fatality; expected number of cancer fatalities for populations, assuming a risk of 0.0005 latent cancer fatality per rem for members of the public (NCRP 1993a, page 31).

Table 8-45 lists the peak dose rate and time of peak for 1 million years after repository closure for both Inventory Module 1 and the Proposed Action for the intermediate thermal load scenario. The impacts would follow the same pattern as those for the first 10,000 years after repository closure listed in Table 8-43, with the impacts for Module 1 being about 2 to 5 times greater than those for the Proposed Action.

Table 8-46 lists peak radionuclide and alpha particle concentrations in water at four locations for the intermediate thermal load scenario under the Proposed Action and Inventory Module 1. These concentrations would occur 10,000 years after repository closure. The concentrations and the drinking water doses would follow the same pattern as those for the first 10,000 years after repository closure listed in Table 8-43, with the results for Module 1 being commensurately greater than those for the Proposed Action. The analysis derived the consequences at each distance from a different set of 100 simulations. Therefore, fluctuations in the relative concentration of specific nuclides could occur at different distances. The radionuclides that would contribute the most to individual dose in 10,000 years would be iodine-129, technetium-99, and carbon-14.

Table 8-45. Impacts for a maximally exposed individual from groundwater releases of radionuclides during the 1 million years after repository closure for the intermediate thermal load scenario under the Proposed Action and Inventory Module 1.[a]

		Mean		95th-percentile	
Inventory	Maximally exposed individual	Peak dose rate (millirem/year)	Time of peak (years)	Peak dose rate (millirem/year)	Time of peak (years)
Proposed Action	At 5 kilometers[b]	470	296,000	2,800	320,000
	At 20 kilometers	170	804,000	900	712,000
	At 30 kilometers	91	418,000	500	932,000
	At 80 kilometers	32	872,000	120	702,000
Inventory Module 1	At 5 kilometers	2,300	698,000	15,000	342,000
	At 20 kilometers	400	336,000	2,500	712,000
	At 30 kilometers	240	422,000	1,300	752,000
	At 80 kilometers	110	334,000	330	712,000

a. Based on 100 simulations of total system performance for each location, using random samples of uncertain parameters.
b. To convert kilometers to miles, multiply by 0.62137.

Table 8-46. Radionuclide concentrations (picocuries per liter) in water and doses at four locations for the 10,000 years after closure for the intermediate thermal load scenario under the Proposed Action and Inventory Module 1.[a]

		Mean				95th-percentile			
Inventory	Radionuclide	5 km[b]	20 km	30 km	80 km	5 km	20 km	30 km	80 km
Proposed Action	Carbon-14	1.2	1.1	4.4×10^{-1}	1.6×10^{-2}	9.6	5.9	6.7×10^{-1}	4.1×10^{-2}
	Iodine-129	8.0×10^{-2}	5.5×10^{-2}	2.9×10^{-2}	1.1×10^{-3}	7.2×10^{-1}	4.3×10^{-1}	4.8×10^{-2}	2.8×10^{-3}
	Neptunium-237	9.1×10^{-5}	8.0×10^{-9}	7.5×10^{-16}	2.2×10^{-23}	1.3×10^{-6}	4.2×10^{-14}	5.1×10^{-22}	2.4×10^{-24}
	Protactinium-231	1.5×10^{-14}	5.0×10^{-26}	3.8×10^{-26}	3.8×10^{-26}	1.2×10^{-26}	1.6×10^{-24}	1.6×10^{-24}	7.6×10^{-27}
	Plutonium-239	6.9×10^{-6}	3.2×10^{-9}	2.4×10^{-10}	7.0×10^{-13}	6.3×10^{-10}	3.0×10^{-10}	2.7×10^{-12}	2.5×10^{-11}
	Plutonium-242	4.8×10^{-8}	2.2×10^{-11}	1.4×10^{-12}	4.8×10^{-15}	3.5×10^{-12}	1.8×10^{-12}	9.3×10^{-15}	1.7×10^{-13}
	Selenium-79	9.4×10^{-2}	4.3×10^{-4}	2.6×10^{-6}	2.0×10^{-21}	5.0×10^{-1}	1.8×10^{-18}	1.3×10^{-18}	3.1×10^{-21}
	Technetium-99	2.1×10^{1}	1.7×10^{1}	4.5	3.7×10^{-1}	4.3×10^{2}	1.8×10^{2}	1.7×10^{1}	1.1
	Uranium-234	1.9×10^{-5}	4.0×10^{-11}	7.8×10^{-17}	2.9×10^{-23}	1.3×10^{-7}	6.3×10^{-16}	2.9×10^{-23}	2.1×10^{-23}
	Drinking water dose (millirem/ year)	4.1×10^{-2}	3.1×10^{-2}	1.1×10^{-2}	6.5×10^{-4}	6.2×10^{-1}	2.9×10^{-1}	2.9×10^{-2}	1.8×10^{-3}
	Gross alpha	9.8×10^{-5}	1.1×10^{-8}	2.4×10^{-10}	7.0×10^{-13}	1.3×10^{-6}	3.1×10^{-10}	2.7×10^{-12}	2.5×10^{-11}
Inventory Module 1	Carbon-14	4.7	3.7	1.4	1.1×10^{-1}	2.7×10^{1}	4.3×10^{1}	1.8	2.7×10^{-2}
	Iodine-129	3.1×10^{-1}	2.6×10^{-1}	9.9×10^{-2}	7.8×10^{-3}	1.9	3.1	1.3×10^{-1}	2.0×10^{-3}
	Neptunium-237	1.6×10^{-3}	5.1×10^{-8}	1.5×10^{-14}	9.3×10^{-23}	3.4×10^{-6}	8.6×10^{-24}	9.9×10^{-22}	3.4×10^{-24}
	Protactinium-231	2.2×10^{-12}	3.0×10^{-25}	7.4×10^{-26}	7.7×10^{-26}	2.7×10^{-23}	1.1×10^{-26}	3.3×10^{-24}	1.1×10^{-26}
	Plutonium-239	1.8×10^{-4}	7.1×10^{-8}	1.9×10^{-9}	1.2×10^{-12}	1.5×10^{-9}	7.4×10^{-12}	9.2×10^{-12}	3.0×10^{-12}
	Plutonium-242	1.1×10^{-6}	4.5×10^{-10}	8.7×10^{-12}	8.0×10^{-15}	8.4×10^{-12}	4.1×10^{-14}	2.5×10^{-14}	1.7×10^{-14}
	Selenium-79	1.2	2.5×10^{-3}	2.0×10^{-5}	1.0×10^{-20}	4.6	2.8×10^{-17}	3.2×10^{-18}	3.4×10^{-20}
	Technetium-99	1.0×10^{2}	4.7×10^{1}	1.5×10^{1}	3.1	1.3×10^{3}	2.9×10^{2}	7.5×10^{1}	9.0×10^{-1}
	Uranium-234	1.1×10^{-4}	8.1×10^{-10}	4.8×10^{-16}	6.1×10^{-23}	5.5×10^{-7}	3.0×10^{-23}	7.1×10^{-23}	3.0×10^{-23}
	Drinking water dose (millirem/year)	1.9×10^{-1}	1.1×10^{-1}	3.8×10^{-2}	5.0×10^{-3}	1.8	9.9×10^{-1}	1.1×10^{-1}	1.4×10^{-3}

a. The concentrations for the mean and 95th-percentile consequences are those that would yield the mean and 95th-percentile doses.
b. To convert kilometers (km) to miles, multiply by 0.62137.

8.3.1.2.1.3 Low Thermal Load Scenario. Table 8-47 lists the estimated impacts to a maximally exposed individual from groundwater releases of radionuclides during the first 10,000 years after repository closure for the low thermal load scenario under the Proposed Action and Inventory Module 1. The impacts for Module 1 would be nearly the same to 3 times greater compared to those calculated for this scenario under the Proposed Action.

Table 8-47. Impacts for a maximally exposed individual from groundwater releases of radionuclides during the 10,000 years after repository closure for the low thermal load scenario under the Proposed Action and Inventory Module 1.[a]

Inventory	Maximally exposed individual	Mean: Peak dose rate[b] (millirem/year)	Mean: Probability of a LCF[c]	95th-percentile: Peak dose rate[b] (millirem/year)	95th-percentile: Probability of a LCF[c]
Proposed Action	At 5 kilometers[d]	0.13	4.7×10^{-6}	0.16	5.6×10^{-6}
	At 20 kilometers	0.059	2.1×10^{-6}	0.061	2.1×10^{-6}
	At 30 kilometers	0.040	1.4×10^{-6}	0.023	8.1×10^{-7}
	At 80 kilometers	0.00053	1.9×10^{-8}	0.0019	6.6×10^{-8}
Inventory Module 1	At 5 kilometers	0.21	7.5×10^{-6}	0.25	8.8×10^{-6}
	At 20 kilometers	0.12	4.1×10^{-6}	0.12	4.2×10^{-6}
	At 30 kilometers	0.086	3.0×10^{-6}	0.069	2.4×10^{-6}
	At 80 kilometers	0.00066	2.3×10^{-8}	0.0041	1.4×10^{-7}

a. Based on 100 simulations of total system performance for each location, using random samples of uncertain parameters.
b. All peaks occur at or near 10,000 years, indicating that the dose rate would still be rising at the end of the simulation period.
c. LCF = latent cancer fatality; incremental lifetime (70 years) risk of contracting a fatal cancer for individuals and expected number of cancer fatalities for populations, assuming a risk of 0.0005 latent cancer fatality per rem for members of the public (NCRP 1993a, page 31).
d. To convert kilometers to miles, multiply by 0.62137.

Table 8-48 lists population impacts from groundwater releases of radionuclides during the first 10,000 years after repository closure for the low thermal load scenario under the Proposed Action and Inventory Module 1. The population impacts for Module 1 would be higher than those for the Proposed Action under the same thermal load scenario. For example, the population dose in the 70-year period of maximum impacts would be about 6 times greater for Module 1 than for the Proposed Action at the 95th-percentile level. In addition, the 10,000-year integrated dose for the 95th-percentile level would be about 7 times greater for Module 1 than for the Proposed Action. Again, as for the high thermal load scenario, the range of increase in population dose differs from the range of increase for the maximally exposed individual dose because of the difference in the amount of contaminated groundwater (see Section 8.3.1.2.1.1).

Table 8-48. Population impacts from groundwater releases of radionuclides during the 10,000 years after repository closure for the low thermal load scenario under the Proposed Action and Inventory Module 1.[a]

Inventory	Case	Mean: Population dose (person-rem)	Mean: Population LCFs[b]	95th-percentile: Population dose (person-rem)	95th-percentile: Population LCFs[b]
Proposed Action	Peak 70-year lifetime	0.001	5.3×10^{-6}	0.0062	3.1×10^{-6}
	Integrated over 10,000 years	0.27	1.3×10^{-4}	0.12	6.0×10^{-5}
Inventory Module 1	Peak 70-year lifetime	0.048	2.4×10^{-5}	0.039	1.9×10^{-5}
	Integrated over 10,000 years	1.0	5.2×10^{-4}	0.83	4.2×10^{-4}

a. Based on 100 simulations of total system performance for each location, using random samples of uncertain parameters.
b. LCF = latent cancer fatality; incremental lifetime (70 years) risk of contracting a fatal cancer for individuals and expected number of cancer fatalities for populations, assuming a risk of 0.0005 latent cancer per rem for members of the public (NCRP 1993a, page 31).

Table 8-49 lists the peak dose rate and time of peak for 1 million years after repository closure for both Inventory Module 1 and the Proposed Action for the low thermal load scenario. The impacts would follow the same pattern as those for the first 10,000 years after repository closure listed in Table 8-23, with the impacts for Module 1 being approximately the same to 3 times greater than those for the Proposed Action.

Table 8-49. Impacts for a maximally exposed individual from groundwater releases of radionuclides during 1 million years after repository closure for the low thermal load scenario under the Proposed Action and Inventory Module 1.[a]

		Mean		95th-percentile	
Inventory	Maximally exposed individual	Peak dose rate (millirem/year)	Time of peak (years)	Peak dose rate (millirem/year)	Time of peak (years)
Proposed Action	At 5 kilometers[b]	630	296,000	3,600	320,000
	At 20 kilometers	160	804,000	860	334,000
	At 30 kilometers	73	400,000	360	308,000
	At 80 kilometers	44	824,000	160	726,000
Inventory Module 1	At 5 kilometers	1,100	296,000	9,100	342,000
	At 20 kilometers	200	336,000	1,200	804,000
	At 30 kilometers	130	398,000	680	308,000
	At 80 kilometers	43	946,000	170	746,000

a. Based on 100 simulations of total system performance for each location, using random samples of uncertain parameters.
b. To convert kilometers to miles, multiply by 0.62137.

Table 8-50 lists peak radionuclide and alpha particle concentrations in water at four locations for the low thermal load scenario under the Proposed Action and Inventory Module 1. The peak concentrations would be for 10,000 years after repository closure. The concentrations and the drinking water doses

Table 8-50. Radionuclide concentrations (picocuries per liter) in water and doses at four locations for 10,000 years after closure for the low thermal load scenario under the Proposed Action and Inventory Module 1.

		Mean[a]				95th-percentile			
Inventory	Radionuclide	5 km[b]	20 km	30 km	80 km	5 km	20 km	30 km	80 km
Proposed Action	Carbon-14	1.6	7.9×10^{-1}	4.0×10^{-1}	6.7×10^{-3}	5.6	5.9	2.1×10^{-1}	3.1×10^{-2}
	Iodine-129	1.0×10^{-1}	5.0×10^{-2}	2.3×10^{-2}	4.8×10^{-4}	4.0×10^{-1}	1.5×10^{-1}	1.8×10^{-25}	2.4×10^{-3}
	Neptunium-237	7.3×10^{-4}	9.3×10^{-12}	2.2×10^{-16}	9.1×10^{-23}	1.4×10^{-6}	4.0×10^{-12}	7.1×10^{-25}	7.1×10^{-25}
	Protactinium-231	1.4×10^{-16}	2.6×10^{-24}	7.8×10^{-26}	7.9×10^{-26}	1.6×10^{-16}	7.7×10^{-27}	2.2×10^{-27}	2.2×10^{-27}
	Plutonium-239	9.4×10^{-5}	2.4×10^{-9}	1.1×10^{-9}	6.5×10^{-13}	2.5×10^{-13}	7.7×10^{-16}	4.0×10^{-14}	7.7×10^{-13}
	Plutonium-242	6.9×10^{-7}	1.6×10^{-11}	5.5×10^{-12}	4.5×10^{-15}	3.2×10^{-16}	4.3×10^{-18}	2.8×10^{-16}	5.5×10^{-15}
	Selenium-79	2.7×10^{-1}	4.4×10^{-6}	8.9×10^{-12}	7.8×10^{-22}	3.2	1.8×10^{-7}	1.7×10^{-21}	1.6×10^{-20}
	Technetium-99	1.7×10^{1}	7.3	4.5	7.2×10^{-2}	1.9	1.4×10^{1}	6.3	3.4×10^{-1}
	Uranium-234	3.1×10^{-6}	1.5×10^{-12}	4.1×10^{-16}	1.5×10^{-23}	2.0×10^{-7}	6.7×10^{-11}	6.2×10^{-24}	6.2×10^{-24}
	Drinking water dose (millirem/year)	4.4×10^{-2}	1.9×10^{-2}	1.0×10^{-2}	1.8×10^{-4}	9.5×10^{-2}	5.3×10^{-2}	7.0×10^{-3}	9.1×10^{-4}
	Gross alpha	8.2×10^{-4}	1.4×10^{-9}	1.1×10^{-9}	6.6×10^{-13}	1.4×10^{-6}	4.0×10^{-12}	4.0×10^{-14}	7.7×10^{-13}
Inventory Module 1	Carbon-14	2.7×10^{-0}	1.4×10^{0}	8.9×10^{-1}	1.1×10^{-2}	6.4×10^{0}	4.2	4.9×10^{-1}	5.6×10^{-2}
	Iodine-129	1.7×10^{-1}	1.0×10^{-1}	6.3×10^{-2}	7.2×10^{-4}	4.6×10^{-1}	2.9×10^{-1}	3.6×10^{-2}	2.9×10^{-3}
	Neptunium-237	1.7×10^{-3}	5.3×10^{-12}	8.5×10^{-17}	1.0×10^{-21}	1.4×10^{-9}	6.0×10^{-11}	1.7×10^{-24}	1.7×10^{-24}
	Protactinium-231	8.2×10^{-18}	8.6×10^{-25}	8.0×10^{-26}	8.3×10^{-26}	5.4×10^{-27}	5.4×10^{-27}	5.4×10^{-27}	5.4×10^{-27}
	Plutonium-239	6.1×10^{-4}	1.5×10^{-8}	1.0×10^{-9}	2.0×10^{-12}	7.8×10^{-16}	9.3×10^{-14}	9.8×10^{-14}	5.1×10^{-16}
	Plutonium-242	3.4×10^{-6}	1.2×10^{-10}	4.6×10^{-12}	1.4×10^{-14}	4.0×10^{-18}	6.3×10^{-16}	6.9×10^{-16}	3.3×10^{-18}
	Selenium-79	4.8×10^{-1}	2.2×10^{-4}	7.5×10^{-10}	1.5×10^{-21}	5.6×10^{0}	1.2×10^{-18}	2.1×10^{-21}	3.6×10^{-21}
	Technetium-99	1.5×10^{1}	9.5×10^{0}	8.9×10^{0}	1.6×10^{-1}	2.0×10^{1}	1.3×10^{1}	1.4×10^{1}	3.2×10^{-1}
	Uranium-234	9.1×10^{-6}	3.6×10^{-12}	8.3×10^{-16}	2.7×10^{-23}	6.3×10^{-8}	1.5×10^{-23}	1.5×10^{-23}	1.5×10^{-23}
	Drinking water dose (millirem/year)	6.1×10^{-2}	3.3×10^{-8}	2.3×10^{-2}	3.3×10^{-4}	1.3×10^{-1}	7.9×10^{-2}	2.3×10^{-2}	1.0×10^{-3}
	Gross alpha	2.3×10^{-3}	1.5×10^{-8}	1.0×10^{-9}	2.0×10^{-12}	1.4×10^{-9}	6.0×10^{-11}	9.9×10^{-14}	5.1×10^{-16}

a. The concentrations for the mean and 95th-percentile consequences would be those that yielded the mean and 95th-percentile doses.
b. To convert kilometers (km) to miles, multiply by 0.62137.

would follow the same pattern as for the first 10,000 years after repository closure listed in Table 8-47, with the results for Module 1 being commensurately greater than those for the Proposed Action. The analysis derived the consequences at each distance from a different set of 100 simulations. Therefore, fluctuations in the relative concentration of specific nuclides could occur at different distances. The radionuclides that would contribute the most to individual dose in 10,000 years would be iodine-129, technetium-99, and carbon-14.

8.3.1.2.2 *Waterborne Chemically Toxic Material Impacts*

The Proposed Action impacts described in Chapter 5, Section 5.6.3, for uranium would be about 100,000 times smaller than a threshold concentration based on the reference dose for elemental uranium of 0.003 milligram per kilogram per day (EPA 1999d, all). The Environmental Protection Agency has not established a Maximum Contaminant Level Goal for elemental uranium. The 70-percent increase in uranium inventory for Inventory Module 1 (see Table 8-36) would still result in impacts that were much smaller than the threshold concentration. Therefore, uranium would not present a substantial impact as a chemically toxic material under Module 1.

Using the modeling methods described in Chapter 5 (and in greater detail in Appendix I), DOE analyzed the impacts of chromium as a chemically toxic material for Inventory Module 1. The analysis included all four receptor locations under all three thermal load scenarios for Module 1. Table 8-51 lists results for the first 10,000 years after repository closure under Module 1. The calculated chromium concentrations ranged from about the same to 8 times greater for Module 1 compared to the Proposed Action.

There are two possible comparisons for human health effects for chromium. The Environmental Protection Agency considered safe levels of contaminants in drinking water and the ability to achieve these levels with the best available technology when it established its Maximum Contaminant Level Goals. The Maximum Contaminant Level Goal for chromium is 0.1 milligram per liter (0.0000062 pound per cubic foot) (40 CFR Part 141.51). The other measure for comparison is the reference dose factor for chromium, which is 0.005 milligram per kilogram (0.0004 ounce per pound) of body mass per day (EPA 1998b, all). The reference dose factor represents a level of intake that has no adverse effect on humans. It can be converted to a threshold concentration level for drinking water. The conversion yields essentially the same concentration for the reference dose factor as the Maximum Contaminant Level Goal.

The analysis did not evaluate the groundwater concentrations listed in Table 8-51 for human health effects (for example, latent cancer fatalities) because there is insufficient epidemiological or toxicological data to determine the carcinogenic potency of hexavalent chromium by the oral route of exposure (EPA 1998a, page 48). (Soluble chromium occurs in the hexavalent form; see Appendix I.)

The Alloy-22 that would be used as a corrosion-resistant inner layer of the waste package contains 13.5 percent molybdenum. There is no established toxicity standard for molybdenum (in particular, the Environmental Protection Agency has not established a Maximum Contaminant Level Goal for molybdenum). This does not mean that molybdenum is not toxic, only that there is no standard of toxicity.

During the corrosion of the Alloy-22, molybdenum would behave almost the same as the chromium. Due to the corrosion conditions, molybdenum would dissolve in a highly soluble hexavalent form. Therefore, the source term for molybdenum would be 0.614 times the source term for chromium (the ratio of molybdenum inventory to chromium inventory). All the mechanisms and parameters would be the same

Table 8-51. Peak chromium groundwater concentrations (milligram per liter)[a] for 10,000 years after closure at four locations for high, intermediate, and low thermal load scenarios under the Proposed Action and Inventory Module 1.[b]

Inventory	Thermal load scenario	Maximally exposed individual	Mean	95th-percentile
Proposed Action	High	At 5 kilometers[c]	0.0085	0.037
		At 20 kilometers	0.0028	0.012
		At 30 kilometers	0.0018	0.0063
		At 80 kilometers	0.00022	0.00061
	Intermediate	At 5 kilometers	0.0029	0.0096
		At 20 kilometers	0.0023	0.010
		At 30 kilometers	0.00080	0.0038
		At 80 kilometers	0.000031	0.00015
	Low	At 5 kilometers	0.0046	0.016
		At 20 kilometers	0.0018	0.0083
		At 30 kilometers	0.00067	0.0033
		At 80 kilometers	0.000053	0.00034
Inventory Module 1	High	At 5 kilometers	0.032	0.14
		At 20 kilometers	0.018	0.10
		At 30 kilometers	0.0057	0.027
		At 80 kilometers	0.00029	0.00070
	Intermediate	At 5 kilometers	0.023	0.083
		At 20 kilometers	0.0089	0.042
		At 30 kilometers	0.0032	0.017
		At 80 kilometers	0.00019	0.00057
	Low	At 5 kilometers	0.0093	0.035
		At 20 kilometers	0.0050	0.022
		At 30 kilometers	0.0020	0.0084
		At 80 kilometers	0.000074	0.00026

a. To convert from milligram per liter to pounds per cubic foot, multiply by 0.0000624.
b. Based on 100 simulations of total system performance, using random samples of uncertain parameters.
c. To convert kilometers to miles, multiply by 0.62137.

as those for chromium, so modeling is unnecessary. The analysis assumed that molybdenum would be present in the water at concentrations 0.614 times those reported in Table 8-51 for chromium.

8.3.1.2.3 *Atmospheric Radioactive Material Impacts*

Using the analysis methods described in Section 5.5, DOE estimated the impacts of carbon-14 releases to the atmosphere for Inventory Module 1. Table 8-52 compares these findings to the Proposed Action

Table 8-52. Atmospheric radioactive material impacts for carbon-14.

			For local population within 84 kilometers[a]		
Inventory	Maximum release rate (microcurie per year)	Time of maximum release (years after closure)	Maximum individual dose rate (rem per year)	Maximum population dose (person-rem)	Maximum population LCFs[b]
Proposed Action	0.098	19,000	7.8×10^{-15}	2.2×10^{-10}	1.1×10^{-13}
Inventory Module 1	0.11	27,000	8.8×10^{-15}	2.4×10^{-10}	1.2×10^{-13}

a. 84 kilometers = about 52 miles.
b. LCF = latent cancer fatality; incremental lifetime (70 years) risk of contacting a fatal cancer for individuals and expected number of cancer fatalities for populations, assuming a risk of 0.0005 latent cancer fatality per rem for members of the public (NCRP 1993a, page 31).

carbon-14 impacts. The important difference in the atmospheric carbon-14 impacts for Module 1 and for the Proposed Action is that the number of waste packages containing spent nuclear fuel would increase by approximately 67 percent, providing more carbon-14 for atmospheric release.

The estimated maximum release rate to the air for gaseous-phase carbon-14 would be 0.11 microcurie a year, about 27,000 years after repository closure. This compares to a release rate of 0.098 microcurie per year about 19,000 years after repository closure for the Proposed Action. The 0.11 microcurie-per-year release corresponds to an 8.8×10^{-15} rem-per-year average dose to individuals within 80 kilometers (50 miles). The maximum population dose to the 28,000 people within 80 kilometers would be 2.4×10^{-10} person-rem. This dose rate corresponds to 1.2×10^{-13} latent cancer fatality at the maximum release rate of carbon-14. Over a 70-year period, which corresponds to a lifetime for an individual, this annual dose rate yields a dose of 1.7×10^{-8} rem, corresponding to 8.5×10^{-12} latent cancer fatality during the 70-year period of the maximum release rate. In general, the impacts would be about 13 percent higher for Inventory Module 1 than for the Proposed Action.

8.3.1.3 INCREMENTAL IMPACTS FOR INVENTORY MODULE 2

DOE addressed the long-term consequences from Inventory Module 2 by analyzing the effects of disposing waste packages containing Greater-Than-Class-C and Special-Performance-Assessment-Required wastes in addition to the material in Inventory Module 1. Table 8-35 lists the average inventory of the additional waste packages containing Greater-Than-Class-C and Special-Performance-Assessment-Required wastes. The following sections discuss these impacts in terms of waterborne radioactive releases, chemically toxic materials waterborne release, and atmospheric radioactive material releases.

8.3.1.3.1 *Waterborne Radioactive Material Impacts*

The addition of Greater-Than-Class-C and Special-Performance-Assessment-Required wastes is the only difference between Inventory Modules 1 and 2. Therefore, a complete repetition of the total systems modeling to evaluate the impacts attributable to adding these wastes was unnecessary. Rather, DOE (1998a, Volume 3, pages 2-40 to 2-41) performed a single *expected-value* simulation (using the mean of every probabilistic input parameter) for each thermal load scenario and location, specifying only the Greater-Than-Class-C and Special-Performance-Assessment-Required waste as the radionuclide inventory. The results of these expected-value simulations constitute the additional impacts of Inventory Module 2 over those of Module 1. In addition, they represent the dose attributable solely to the Greater-Than-Class-C and Special-Performance-Assessment-Required waste. By contrasting the expected-value simulation results for Module 2 to the comparable expected-value results for Module 1, the analysis estimated the incremental impact.

Table 8-53 lists the incremental (that is, the increase in) consequences for a maximally exposed individual from the Greater-Than-Class-C and Special-Performance-Assessment-Required wastes in Inventory Module 2 during 10,000 years and 1 million years following repository closure. The increases in Table 8-53 are expressed in terms of the percent increase in peak dose to the maximally exposed individual. Peak impacts from waterborne radioactive materials for Module 2 would be less than 2 percent higher for the first 10,000 years after repository closure and less than one-half of one percent higher for the first 1 million years after repository closure compared to Module 1. Therefore, the waterborne radioactive material impacts for Modules 1 and 2 are essentially equivalent in both periods.

8.3.1.3.2 *Waterborne Chemically Toxic Material Impacts*

The Proposed Action impacts described in Section 5.6.3 for uranium would be about 100,000 times smaller than a threshold concentration based on the reference dose for elemental uranium of 0.003

Table 8-53. Percentage increase in peak dose rate under Inventory Module 2 over the peak dose rate under Inventory Module 1 for a maximally exposed individual during 10,000 and 1 million years after repository closure.

Postclosure period	Maximally exposed individual	Thermal load: High	Intermediate	Low
10,000 years	At 5 kilometers[a]	1.8	0.70	0
	At 20 kilometers	1.6	0.55	0
	At 30 kilometers	0.99	0.0033	0
	At 80 kilometers	0	0	0
1,000,000 years	At 5 kilometers	0.0015	0.0018	0.0069
	At 20 kilometers	0.0043	0.0025	0.0024
	At 30 kilometers	0.0030	0.0046	0.0044
	At 80 kilometers	0.30	0.34	0.29

a. To convert kilometers to miles, multiply by 0.62137.

milligram per kilogram per day (EPA 1999d, all). The Environmental Protection Agency has not established a Maximum Contaminant Level Goal for elemental uranium. The 70-percent increase in the uranium inventory for Inventory Module 2 (see Table 8-36) would result in impacts that would be much smaller than those for the threshold concentration. Therefore, uranium would not present a substantial impact as a chemically toxic material under Module 2.

Using the same modeling methods as those described in Chapter 5 (and in greater detail in Appendix I), the analysis calculated the impacts of chromium as a chemically toxic material for Inventory Module 2. Just as with the radioactive waterborne impacts, the chromium impacts for Module 2 were modeled as an incremental impact over Module 1 using *expected-value* simulations. Table 8-54 lists the results for the first 10,000 years after repository closure in terms of the percentage increase in chromium concentrations at the various well locations over Module 1 impacts.

Table 8-54. Percentage increase in peak chromium groundwater concentrations (milligrams per liter)[a] under Inventory Module 2 over the peak chromium groundwater concentrations for Inventory Module 1 for 10,000 years after repository closure.

Postclosure period	Maximally exposed individual	Thermal load: High	Intermediate	Low
10,000 years	At 5 kilometers[b]	4.5	4.8	15.
	At 20 kilometers	4.5	4.5	4.4
	At 30 kilometers	4.5	4.4	4.3
	At 80 kilometers	4.1	1.5	5.4

a. To convert from milligram per liter to pounds per cubic foot, multiply by 0.0000624.
b. To convert kilometers to miles, multiply by 0.62137.

There are two possible comparisons for human health effects for chromium. The Environmental Protection Agency considered safe levels of contaminants in drinking water and the ability to achieve these levels with the best available technology when it established its Maximum Contaminant Level Goals. The Maximum Contaminant Level Goal for chromium is 0.1 milligram per liter (0.0000062 pound per cubic foot) (40 CFR Part 141.51). The other measure for comparison is the reference dose factor for chromium, which is 0.005 milligram per kilogram (0.0004 ounce per pound) of body mass per day (EPA 1998a, all). The reference dose factor represents a level of intake that has no adverse effect on humans. It can be converted to a threshold concentration level for drinking water. The conversion yields essentially the same concentration for the reference dose factor as the Maximum Contaminant Level Goal.

The analysis made no attempt to express the groundwater concentrations listed in Table 8-54 in terms of human health effects (for example, latent cancer fatalities) because there is a lack of sufficient epidemiological or toxicological data for determining the carcinogenicity of hexavalent chromium by the oral route of exposure (EPA 1998a, page 48) [soluble chromium occurs in the hexavalent form (see Appendix I)].

The Alloy-22 that would be used as a corrosion resistant inner layer of the waste package contains 13.5 percent molybdenum. There is no established toxicity standard for molybdenum (in particular, the Environmental Protection Agency has not established a Maximum Contaminant Level Goal for molybdenum). This does not mean that molybdenum is not toxic, only that there is no standard of toxicity.

During the corrosion of the Alloy-22, molybdenum would behave almost the same as the chromium. Due to the corrosion conditions, molybdenum would dissolve in a highly soluble hexavalent form. Therefore, the source term for molybdenum would be 0.614 times the source term for chromium (the ratio of molybdenum inventory to chromium inventory). All the mechanisms and parameters would be the same as those for chromium, so modeling is unnecessary. The analysis assumed that molybdenum would be present in the water at concentrations 0.614 times those listed in Table 8-54 for chromium.

8.3.1.3.3 *Atmospheric Radioactive Material Impacts*

DOE did not perform detailed analyses of impacts from atmospheric releases of carbon-14 for Inventory Module 2. While the waste packages that would be in addition to those for Module 1 would have an average carbon-14 inventory about triple that of the average waste package of commercial spent nuclear fuel, very little of the additional carbon-14 would be in gaseous form (see Table 8-38). This is because only commercial spent nuclear fuel waste packages contain a relatively large amount of gaseous carbon-14, and Module 2 includes the same number of commercial spent nuclear fuel packages as Module 1. The waste packages containing Greater-Than-Class-C waste and Special-Performance-Assessment-Required wastes that would not contain large quantities of gaseous carbon-14. Therefore, the atmospheric radioactive material impacts for Module 2 would be essentially the same as those for Module 1.

8.3.2 CUMULATIVE IMPACTS FROM INVENTORY MODULE 1 OR 2 AND OTHER FEDERAL, NON-FEDERAL, AND PRIVATE ACTIONS

This section discusses potential cumulative impacts from other Federal, non-Federal, and private actions that could contribute to doses at the locations considered in the performance assessment of the Yucca Mountain Repository. The actions identified with the potential for long-term cumulative impacts are past, present, and reasonably future actions at the Nevada Test Site and past actions at the low-level radioactive waste disposal facility near Beatty, Nevada.

8.3.2.1 Past, Present, and Reasonably Foreseeable Future Actions at the Nevada Test Site

Historically, the primary mission of the Nevada Test Site was to conduct nuclear weapons tests. Nuclear weapons testing and other activities have resulted in radioactive contamination and have the potential for radioactive and nonradioactive contamination of some areas of the Nevada Test Site. These areas and the associated contamination and the potential for contamination were evaluated for potential cumulative impacts with postclosure impacts from the proposed Yucca Mountain Repository. This section discusses these Nevada Test Site activities, the locations where these activities occurred, and the potential for cumulative long-term impacts with the repository.

Unless otherwise identified, DOE derived the information in this section from the Nevada Test Site Final EIS (DOE 1996f, all). The Yucca Mountain Repository site is in the southwestern portion of the Nevada Test Site along its western boundary, as shown in Figure 8-3.

At the Nevada Test Site, seven categories of activities have resulted in radioactive contamination or have the potential to result in radioactive and nonradioactive contamination:

1. *Atmospheric Weapons Testing.* One hundred atmospheric detonations occurred before the signing of the Limited Test Ban Treaty in August 1963. Atmospheric tests included detonations at ground level, from towers or balloons, or from airdrops.

2. *Underground Nuclear Testing.* Approximately 800 underground nuclear tests have occurred at the Nevada Test Site. Figure 8-3 shows the locations of these tests in relation to Yucca Mountain. They included deep underground tests to study weapons effects, designs, safety, and reliability, and shallow underground tests to study the peaceful application of nuclear devices for cratering.

3. *Safety Tests.* Between 1954 and 1963, 16 above-ground tests studied the vulnerability of weapons designs to possible accident scenarios.

4. *Nuclear Rocket Development Station.* Twenty-six experimental tests of reactors, nuclear engines, ramjets, and nuclear furnaces occurred between 1959 and 1973. Figure 8-3 shows the location of the Nuclear Rocket Development Station.

5. *Shallow Land Radioactive Waste Disposal.* DOE disposed of some radioactive waste generated during the testing in shallow cells, pits, and trenches. Because of the site characteristics, notably the absence of a groundwater pathway, shallow burial continues to be an important waste disposal activity at the Nevada Test Site. Section 8.3.2.1.3 discusses present and potential future low-level radioactive waste disposal activities.

6. *Crater Disposal.* DOE disposed of contaminated soils and equipment collected during the decontamination of atmospheric testing areas and the consolidation of radioactively contaminated structures, and other bulk wastes, in subsidence craters at Yucca Flat in Area 3. Figure 8-3 shows the location of the Area 3 Radioactive Waste Management Site.

7. *Greater Confinement Disposal.* In 1981, greater confinement disposal began at Area 5 for low-level radioactive wastes not suitable for shallow land disposal. Figure 8-3 shows the location of the Area 5 Radioactive Waste Management Site.

Table 8-55 lists the approximate inventory for each of these categories. The unimportance of several categories is apparent; atmospheric testing, shallow underground testing, safety testing, and nuclear rocket development all resulted in a less-than-40-curie source term. Additionally, the inventories represented by crater disposal and shallow-land disposal were determined to not be important to cumulative impact considerations. Only the deep underground testing and greater confinement disposal categories represent substantial inventories that could, when combined with the repository inventory, result in increased cumulative impacts.

8.3.2.1.1 *Underground Nuclear Testing*

Declassification of the summed radionuclide source term (total radioactivity of all radionuclides) that remains within 100 meters (330 feet) of the water table has enabled an updated estimate of the total radionuclide source term remaining below the ground surface as a result of underground testing. As of

Table 8-55. Summary of radioactivity on the Nevada Test Site (January 1996).[a]

Source	Area	Environmental media	Major known isotopes or wastes	Depth range	Approximate inventory (curies)
Atmospheric weapons testing	Aboveground nuclear weapon proving area	Surficial soils and test structures	Americium, cesium, cobalt, plutonium, europium, strontium	At land surface	20
Underground testing: shallow underground tests	Underground nuclear testing areas	Soils and alluvium	Americium, cesium, cobalt, europium, plutonium, strontium	Less than 61 meters[b]	1 at land surface; unknown at depth
Underground testing: deep underground tests	Underground nuclear testing areas	Soils, alluvium, and consolidated rock	Tritium, fission, and activation products	Typically less than 640 meters, but might be deeper	More than 300 million, approximately 110 million are below or within 100 meters (330 feet) above the water table and are available for groundwater transport
Safety tests	Aboveground experimental areas	Surficial soils	Americium, cesium, cobalt, plutonium, strontium	Less than 0.9 meter	35
Nuclear rocket development area	Nuclear rocket motor, reactor, and furnace testing area	Surficial soils	Cesium, strontium	Less than 3 meters	1
Shallow land disposal	Waste disposal landfills	Soils and alluvium	Dry-packaged low-level and mixed wastes	Less than 9 meters	500,000[c,d]
Crater disposal	Test-induced subsidence crater with sidewalls, cover, and drainage	Soils and alluvium	Bulk contaminated soils and equipment	Less than 30 meters	1,250[c,e]
Greater confinement disposal	Monitored underground waste disposal	Soils and alluvium	Tritium, americium	37 meters	9.3 million[c,f]

a. Source: DOE (1996f, page 4-6).
b. To convert meters to feet, multiply by 3.2808.
c. Inventory at time of disposal (not corrected for decay).
d. Inventory does not include prospective future low-level radioactive and mixed waste disposal (see Section 8.3.2.1.3).
e. Volume of waste considered for inventory was approximately 205,000 cubic meters (7.25 million cubic feet).
f. Volume of waste considered for inventory was approximately 300 cubic meters (10,000 cubic feet).

January 1, 1994, the estimated total radionuclide source term for all tests was 300 million curies (DOE 1996f, page 4-85). Of that amount, an estimated 110 million curies were below or within about 100 meters (330 feet) above the water table (DOE 1996f, page 4-126). There is some uncertainty related to the Nevada Test Site estimates; the Nevada Test Site EIS contains additional details on the development of the estimated total source term from underground nuclear tests (DOE 1996f, pages 4-126 to 4-130). There is recent evidence of plutonium migration from one underground test. Groundwater monitoring results indicate that plutonium has migrated about 1.3 kilometers (0.8 mile), possibly facilitated by the movement of very small and relatively mobile particles called *colloids* in the groundwater (Kersting et al.

1999, page 59). No radioactive contamination attributable to underground tests has been detected in monitoring wells off the Nevada Test Site. DOE is conducting further monitoring and research to study these and other potential radionuclide migration phenomenon.

The above information indicates that groundwater could transport radionuclides produced during underground nuclear tests at the Nevada Test Site. This transport could ultimately result in releases from underground testing at the same sites analyzed for releases from the repository in this EIS. Long-term performance assessment calculations for the underground testing inventory have not been made with the same rigor as was done for the proposed Yucca Mountain Repository. Nevertheless, DOE calculated a conservative, maximum potential individual dose that would be likely to result from the underground test inventory. The assumptions of this bounding calculation were:

- The total 300-million-curie radionuclide inventory from underground testing, excluding the tritium inventory, would be available for transport. [Tritium's short half-life (about 12.5 years) would mean that the tritium inventory would be depleted through radioactive decay to insignificant levels in about 200 years, long before any Yucca Mountain releases would occur. Tritium constitutes about 90 percent of the total underground testing inventory (DOE 1996f, Table 4-27, pages 4-128 and 4-129)].

- The total underground testing inventory available for transport would migrate through the same locations as those considered in this EIS for dose calculations for releases from the repository. [This is very conservative because much of the water migrating from the underground test locations would discharge to locations other than any releases from the proposed repository, such as Sarcobatus Flats, Oasis Valley, Ash Meadows, or the Amargosa Desert (DOE 1996f, page 4-117)].

- Conservative dilution factors would account for isotopic dilution of carbon-14 by interaction with nonradioactive carbon, removal of technetium through precipitation caused by reducing conditions along the carbonate aquifer flowpaths, dilution in uncontaminated water from the recharge over the Nevada Test Site, and aquifer mixing in transport.

Using the aforementioned conservative assumptions, the maximum potential dose from the underground testing inventory is calculated to be 0.2 millirem per year (based on calculations in the Viability Assessment for radionuclides that would influence dose in 10,000 years). Thus, the maximum cumulative impact of the Proposed Action in 10,000 years, for example [using the mean impact at 20 kilometers (12 miles); see Table 8-39], would be 0.22 millirem per year (the Yucca Mountain Repository impact) plus 0.2 millirem per year (the conservative maximum dose estimate resulting from underground testing), or 0.42 millirem per year. No estimate was made for 1 million years, but the cumulative impact contribution from underground testing is likely to be similar.

There is a high degree of uncertainty associated with this estimate, but the use of bounding assumptions ensures that any reduction in uncertainty would only lower the already low estimated impact. The uncertainty in the estimates is related to several factors. There is a relatively limited amount of information on the groundwater system between the area where underground testing occurred and the Yucca Mountain site. Therefore, the speed of groundwater travel, the relationship between aquifers (mixing), dilution rates, and other factors can only be generally approximated. In addition, the estimates of contaminant travel time from the underground tests are based on one data set from one well over a very short time (fewer than 50 years) and then extrapolated to 10,000 years. As mentioned above, these impact estimates were not performed with the same rigor as those for the long-term performance assessment for the repository.

8.3.2.1.2 *Greater Confinement Disposal*

The waste disposed of under Greater Confinement Disposal constitutes a radiological source term that is less than 10 percent of the repository radionuclide source term immediately available for groundwater transport when the first waste packages initially degrade (that is, 2 percent of the total repository radionuclide source term). Therefore, Greater Confinement Disposal wastes could result in an increase of no more than approximately 10 percent to the impacts associated with the repository.

8.3.2.1.3 *Future Nevada Test Site Low-Level Waste Disposal*

The Nevada Test Site is a disposal site for low-level radioactive waste generated by DOE-approved generators. Managed radioactive waste disposal operations began in the early 1960s, and DOE has disposed of low-level, transuranic, mixed, and classified low-level wastes in selected pits, trenches, landfills, and boreholes on the Nevada Test Site. Environmental impacts from the disposal of low-level waste at the Nevada Test Site are discussed in the Nevada Test Site Final EIS (DOE 1996f, pages 2-15 to 2-17). The current source term of low-level and mixed wastes in shallow land disposal on the Nevada Test Site does not constitute a substantial inventory in relation to the radionuclide source term immediately available for groundwater transport from the repository when the first waste packages initially degrade (that is, 2 percent of the total repository radionuclide source term). However, shallow burial continues to be an important waste disposal activity at the Nevada Test Site. Therefore, this section evaluates reasonably foreseeable future activities in this category as a potential cumulative impact.

Waste disposal activities on the Nevada Test Site occur at two specific locations. They are the Area 3 and Area 5 Radioactive Waste Management Sites. The Area 3 Radioactive Waste Management Site is on Yucca Flat and covers an area of approximately 0.2 square kilometer (50 acres). DOE uses conventional landfill techniques to dispose of contaminated debris from the Nevada Test Site Atmospheric Testing Debris Disposal Program and packaged bulk low-level waste from other DOE sites in subsidence craters from underground nuclear tests. The estimated total remaining capacity for low-level waste in the Area 3 site is 1.8 million cubic meters (64 million cubic feet) (DOE 1998l, Section A.5.2).

DOE has used the Area 5 Radioactive Waste Management Site since 1961 to dispose of low-level waste and classified low-level waste from Nevada Test Site operations. In 1978, the Nevada Test Site began accepting low-level waste generated by other DOE sites. The total area of the Area 5 site is 3 square kilometers (740 acres). The developed portion occupies 0.37 square kilometer (92 acres) in the southeast corner and contains 17 landfill cells (pits and trenches), 13 Greater Confinement Disposal boreholes, and a transuranic waste storage pad. DOE proposes to locate the Mixed Waste Disposal Unit, which will be a landfill, on about 0.18 square kilometers (45 acres) of the Area 5 site, immediately north of the developed Radioactive Waste Management Site landfill area. The design has been completed, the unit has been included in the Resource Conservation and Recovery Act permit application, and the environmental assessment is being updated. The estimated total remaining capacity for low-level waste in the Area 5 Radioactive Waste Management Site is 1.2 million cubic meters (42 million cubic feet) (DOE 1998l, Section A.5.3).

DOE projects the total life cycle of low-level waste disposal at the Nevada Test Site to be 217,000 cubic meters (7,700,000 cubic feet) of low-level waste by volume (DOE 1998l, Table 2.9):

- 22,000 cubic meters (78,000 cubic feet) during the period from 1996 through 2000
- 85,000 cubic meters (3,000,000 cubic feet) during the period from 2001 through 2030
- 110,000 cubic meters (3,900,000 cubic feet) during the period from 2031 through 2070

To date, DOE has projected only the volumetric waste disposal, not the total radioactivity associated with future low-level waste that it would dispose of. Radiological performance assessment information is required to provide a more accurate evaluation of disposal criteria (DOE 1998i, Executive Summary).

The Final Waste Management Programmatic EIS (DOE 1997b, Summary) reported volumes of radioactive waste DOE may dispose of at the Nevada Test Site for “current plus 20 years” of waste disposal. The current inventory plus 20 years of additional disposal inventory would total 3,000 cubic meters (106,000 cubic feet) of low-level mixed waste, 1,700 cubic meters (60,000 cubic feet) of low-level waste, and 610 cubic meters (21,500 cubic feet) of transuranic waste (DOE 1997b, Summary, Page 102). The Nevada Test Site Final EIS (DOE 1996f, Table 4-1, page 4-6) estimates the total current inventory already in shallow disposal at the Nevada Test Site to be 500,000 curies at the time of disposal (uncorrected for decay to the present time).

According to the Final Waste Management Programmatic EIS, the only expected groundwater impacts from low-level mixed, low-level radioactive, and transuranic waste disposal at the Nevada Test Site in excess of regulatory limits are for the hazardous chemicals 1,2-dichloroethane, methylene chloride, and benzene, and those only under Regionalized Alternative 3 and the Preferred Alternative in that EIS (DOE 1997b, page 11-61). None of these hazardous chemicals would be in the Yucca Mountain Repository inventory, so there would be no potential cumulative impacts from those chemicals from the Proposed Action or Inventory Module 1 or 2.

In summary, the source term of shallow-land disposal sites for past and reasonably foreseeable future disposal at the Nevada Test Site would be small in comparison to the radionuclide source term available for groundwater transport from the repository. Therefore, cumulative long-term impacts from shallow-land disposal at the Nevada Test Site with the repository, if any, would be very small.

8.3.2.2 Past Actions at Beatty Low-Level Radioactive Waste Disposal Facility

A low-level radioactive waste disposal facility, formerly operated by U.S. Ecology, a subsidiary of American Ecology, is 16 kilometers (10 miles) southeast of Beatty, Nevada, and 180 kilometers (110 miles) northwest of Las Vegas. This site is about 15 kilometers (9.3 miles) west of the proposed Yucca Mountain Repository (see Figure 8-2). The disposal facility, which opened in 1962, covers roughly 0.14 square kilometer (35 acres) of unlined trenches. It remains open for hazardous waste disposal, but acceptance of low-level radioactive waste ended December 31, 1992 (DOE 1997p, Chapter 4, Table 4-17). The Nevada State Health Division formally accepted permanent custody of the low-level radioactive commercial waste disposal in a letter to American Ecology dated December 30, 1997 (AEC 1998, all).

From 1962 through 1992, the inventory shipped to the Beatty low-level radioactive waste facility totaled 137,000 cubic meters (4.8 million cubic feet) in volume (DOE 1997p, Chapter 4, Table 4-17) with radioactivity of about 640,000 curies (DOE 1997p, Chapter 4, Table 4-18). The radioactivity in this sum was measured by year of shipment (that is, it is not corrected for decay since that time).

The Manifest Information Management System (MIMS 1999, all) calculated the total radionuclide inventory the Beatty facility received from 1986 through 1992, which represents 29 percent of the total undecayed inventory at that facility. Even if multiplied by a factor of 3 to 4 to compensate for the period (1962 to 1985) for which the Manifest Information Management System did not provide information, the source term represents a small percentage of the radionuclide source term immediately available for groundwater transport from the repository when the first waste packages initially degrade (that is, 2 percent of the total repository radionuclide source term). Therefore, cumulative long-term impacts from the Beatty Low-Level Radioactive Waste Disposal Facility with the repository would be very small.

8.4 Cumulative Transportation Impacts

This section discusses the results of the cumulative impact analysis of transportation. Paralleling the transportation analyses of the Proposed Action in Chapter 6, potential national transportation cumulative impacts from Inventory Module 1 or 2, and past, present, and reasonably foreseeable future actions, are presented in Section 8.4.1. Potential cumulative impacts with construction and operation of the Nevada transportation implementing rail and heavy-haul truck alternatives are included in Section 8.4.2.

The shipment of Inventory Module 1 or 2 to the repository would use the same transportation routes, but would take more shipments and an additional 14 years compared to the Proposed Action. Table 8-2 lists the estimated number of shipments for Modules 1 and 2. Impacts from Module 1 or 2 would be similar because the shipping rate would be the same for spent nuclear fuel and high-level radioactive waste and only about 3 percent more shipments would be made over the 38-year period under Module 2 to transport Greater-Than-Class-C and Special-Performance-Assessment-Required wastes. Because the difference in impacts between Inventory Modules 1 and 2 would be small, the following discussions present the impacts from both modules as being the same.

8.4.1 NATIONAL TRANSPORTATION

This section describes potential cumulative impacts from shipping Inventory Module 1 or 2 from commercial nuclear generating sites and DOE facilities to the proposed Yucca Mountain Repository (Section 8.4.1.1). Section 8.4.1.2 presents potential cumulative national transportation impacts for the Proposed Action and Module 1 or 2 when combined with past, present, and reasonably foreseeable future shipments of radioactive material.

8.4.1.1 Inventory Module 1 or 2 Impacts

This section describes the potential cumulative impacts of loading operations at generating sites and incident-free radiological impacts, vehicle emission impacts, and accident impacts associated with transportation activities for Inventory Module 1 or 2. Cumulative impact results are provided for the mostly legal-weight truck and mostly rail scenarios which are described in Chapter 6. The section also describes potential cumulative impacts from transportation of other materials, personnel, and repository-generated waste for Modules 1 or 2. Appendix J contains additional detailed analysis results.

Loading operations would be extended for an additional 14 years to load the greater quantities of spent nuclear fuel and high-level radioactive waste under Inventory Module 1 or 2. The impacts of routine loading operations described for the Proposed Action in Chapter 6, Section 6.2.2, would increase for Module 1 or 2 due to the additional inventory. DOE would not expect any releases of radioactive material from loading operations that would cause public impacts from either the Proposed Action or Module 1 or 2. Table 8-56 lists estimated radiological and industrial hazard impacts to involved workers for the routine loading operations under Module 1 or 2. The Proposed Action impacts are listed for comparison.

Because noninvolved workers would not have tasks that involved radioactive exposure, there would be no or very small radiological impacts to noninvolved workers. For the reasons identified in Chapter 6, Section 6.1.2.2, industrial hazard impacts to noninvolved workers would be about 25 percent of the impacts to the individual worker shown in Table 8-56.

The impacts of loading accident scenarios under Inventory Module 1 or 2 would be the same as those described for the Proposed Action in Chapter 6, Section 6.2.4.1. The same type of single accident event and its impacts are applicable to shipments under the Proposed Action or Module 1 or 2. As summarized

Table 8-56. Radiological and industrial hazard impacts to involved workers from loading operations.[a,b]

Impact	Proposed Action[b]: Mostly legal-weight truck scenario	Proposed Action[b]: Mostly rail scenario	Inventory Module 1 or 2: Mostly legal-weight truck scenario	Inventory Module 1 or 2: Mostly rail scenario
Radiological				
Maximally exposed individual				
Dose (rem)[c]	12	12	12	12
Probability of latent cancer fatalities	0.005	0.005	0.005	0.005
Involved worker population				
Dose (person-rem)	14,000	5,000	28,000	9,000
Number of latent cancer fatalities	6	2	11	4
Industrial hazards				
Total recordable cases[d]	150	65	280	110
Lost workday cases[e]	66	29	140	50
Fatalities[f]	0.14	0.06	0.3	0.1

a. Includes all involved workers at all facilities.
b. Source: Chapter 6, Section 6.2.
c. Assumes 500 millirem per year to radiation workers. The average individual exposure was assumed to be 24 years for both the Proposed Action and Inventory Module 1 or 2 since 24 years is a conservatively long time to assume an individual would be involved in loading operations.
d. Total recordable cases (of injury and illness) based on a 1992-1997 DOE complex loss incidence rate of 0.03 (DOE 1999c, all).
e. Lost workday cases based on a 1992-1997 DOE complex loss incidence rate of 0.31.
f. Fatalities based on a 1988-1997 DOE complex loss incidence rate of 0.000029.

in Chapter 6, Section 6.2.4.1, the analysis results indicate that there would be no or very small potential radiological consequences from loading accident scenarios involving spent nuclear fuel or high-level radioactive waste. These consequences would bound the consequences from similar accidents involving Greater-Than-Class-C or Special-Performance-Assessment-Required waste because of the lower available radionuclide inventory (see Appendix A).

Table 8-57 lists radiological impacts to involved workers and the public and vehicle emission impacts from incident-free transportation for the mostly legal-weight truck and mostly rail scenarios. The analysis

Table 8-57. Radiological and vehicle emission impacts from incident-free national transportation.

Category	Proposed Action[a,b]: Mostly legal-weight truck scenario[d]	Proposed Action[a,b]: Mostly rail scenario[e]	Inventory Module 1 or 2[c]: Mostly legal-weight truck scenario[d]	Inventory Module 1 or 2[c]: Mostly rail scenario[e]
Involved worker				
Collective dose (person-rem)	11,000	1,900 - 2,300	20,000	3,000 - 3,800
Estimated number of latent cancer fatalities	4.5	0.77 - 0.93	8.0	1.2 - 1.5
Public				
Collective dose (person-rem)	35,000	3,300 - 5,000	62,000	5,000 - 8,100
Estimated number of latent cancer fatalities	18	1.6 - 2.5	31	2.5 - 4.0
Estimated vehicle emission-related fatalities	0.6	0.3	1.1	0.46 - 0.52

a. Source: Chapter 6, Section 6.2.3.
b. Impacts are totals for shipments over 24 years.
c. Impacts are totals for shipments over 38 years.
d. Includes rail shipments of naval spent nuclear fuel to Nevada, and intermodal transfer station and heavy-haul truck operations for this fuel in Nevada.
e. Includes legal-weight truck shipments from commercial nuclear generator sites that do not have the capacity to handle or load rail casks, and the rail and heavy-haul truck implementing alternatives for Nevada described in Chapter 6.

of impacts for the mostly legal-weight truck scenario assumed that shipments would use commercial motor carriers for highway transportation and general freight commercial services for rail transportation for the naval spent fuel shipments that cannot be transported by legal-weight trucks. The mostly rail analysis accounts for legal-weight truck shipments that would occur for the commercial nuclear generator sites that do not have the capacity to handle or load rail casks. In addition, for the mostly rail analysis, DOE assumed that it would use either a branch rail line or heavy-haul trucks in conjunction with an intermodal transfer station in Nevada to transport the large rail casks to and from the repository. The range provided in the table for the mostly rail scenario addresses the different possible rail and heavy-haul truck implementing alternatives described in Chapter 6. The lower end of the range reflects use of a branch rail line in Nevada and the upper end of the range reflects use of heavy-haul trucks in Nevada. The involved worker impacts in Table 8-57 include estimated radiological exposures of truck and rail transportation crews and security escorts for legal-weight truck and rail shipments; the public doses account for the public along the route, the public sharing the route, and the public during stops. The Inventory Module 1 or 2 impacts would exceed those of the Proposed Action due to the additional number of shipments.

DOE does not expect radiological impacts for maximally exposed individuals to change from the Proposed Action due to the conservative assumptions used in the analysis of the Proposed Action (see Chapter 6, Section 6.2.3). The assumptions for estimating radiological dose include the use of the maximum allowed dose rate and conservative estimates of exposure distance and time. For example, the U.S. Department of Transportation maximum allowable dose rate of 10 millirem per hour at a distance of 2 meters (6.6 feet) [40 CFR 173.44(b)]was used for estimating exposure to individuals. In addition, the conservative assumptions for exposure distance and time for workers (that is, crew members, inspectors, railyard crew member) and the public (that is, resident along route, person in a traffic jam, person at a service station, resident near a rail stop) for the Proposed Action are unlikely to be exceeded for Inventory Module 1 or 2 (see Chapter 6, Section 6.2.3).

Table 8-58 lists the radiological accident risk and traffic fatalities for transportation by mostly legal-weight truck and mostly rail for Inventory Module 1 or 2. The radiological accident risk measures the total impact of transportation accidents over the entire shipping campaign (24 years for the Proposed Action and 38 years for Module 1 or 2). The consequences from a maximum reasonably foreseeable accident scenario would be identical to those discussed for the Proposed Action (see Chapter 6, Sections 6.2.4.2.1 and 6.2.4.2.2) because the parameters and conditions for the hypothetical accident event involving spent nuclear fuel or high-level radioactive waste would be the same for a shipment under the Proposed Action or Module 1 or 2. In addition, the hypothetical accident would be bounding for accident scenarios involving Greater-Than-Class-C and Special-Performance-Assessment-Required wastes.

Table 8-58. Accident risk for mostly legal-weight truck and mostly rail scenarios.

	Proposed Action[a]		Inventory Module 1 or 2	
Category	Mostly legal-weight truck scenario	Mostly rail scenario	Mostly legal-weight truck scenario	Mostly rail scenario
Radiological accident risk				
Collective dose risk (person-rem)	130	42 – 47	210	64 – 72
Estimated number of latent cancer fatalities	0.07	0.021 - 0.024	0.10	0.032 – 0.036
Traffic accident fatalities	3.9	2.7 – 3.6	7.0	4.6 – 6.2

a. Source: Chapter 6, Section 6.2.4.2.

As summarized in Chapter 6, Section 6.1.3, and further described in Appendix J, in addition to the transportation of spent nuclear fuel and high-level radioactive waste to the repository, other material would require transportation to and from the proposed repository. These materials would include construction materials, consumables, disposal containers, office and laboratory supplies, mail, and laboratory samples. Required transportation would also include personnel commuting to the Yucca Mountain site and the shipment of repository-generated wastes offsite for treatment, storage, or disposal. The implementation of Inventory Module 1 or 2 would increase this transportation as a result of the additional required subsurface development and the longer time required for repository development, emplacement, and closure. However, even with the increased transportation of other material, personnel, and repository-generated wastes for Module 1 or 2, DOE would expect these transportation impacts to be small contributors to the total transportation impacts on a local, state, and national level with no large cumulative impacts based on the analysis of the Proposed Action in Section 6.1.3. The annual air quality impacts for Inventory Module 1 or 2 would be the same as those conservatively estimated in Section 6.1.3 and, therefore, no cumulative air quality impacts would be expected in the Las Vegas airshed, which is in nonattainment for carbon monoxide. Table 8-59 summarizes fatalities from transporting other materials, personnel, and repository-generated waste. The estimated fatalities assume truck shipments which would have higher potential impacts than shipments by rail. The Proposed Action impacts are listed in the table for comparison.

Table 8-59. Impacts from transportation of materials, consumables, personnel, and waste.[a,b]

Category	Proposed Action: Kilometers[c] traveled	Proposed Action: Fatalities	Inventory Module 1 or 2: Kilometers traveled (Module 1/Module 2)	Inventory Module 1 or 2: Fatalities (Module l/Module 2)
Materials (including disposal containers)	130,000,000	2.5	225,000,000	4.2
Personnel	450,000,000	6.0	650,000,000	8.6
Repository-generated waste				
Hazardous	110,000	0.002	170,000/200,000	0.03/0.04
Low-level radioactive	460,000	0.008	750,000/860,000	0.01/0.02
Nonhazardous solid	560,000	0.01	660,000	0.01
Dual-purpose canisters	1,600,000	0.03	2,700,000	0.05
Totals	**580,000,000**	**8.6**	**1,100,000,000**	**12.9**

a. Totals might differ from sums due to rounding.
b. Source: Appendix J.
c. To convert kilometers to miles, multiply by 0.62137.

8.4.1.2 Cumulative Impacts from the Proposed Action, Inventory Module 1 or 2, and Other Federal, Non-Federal, and Private Actions

The overall assessment of cumulative national transportation impacts for past, present, and reasonably foreseeable future actions concentrated on the cumulative impacts of offsite transportation, which would yield potential radiation doses to a greater portion of the general population than onsite transportation and would result in fatalities from traffic accidents. The collective dose to workers and to the general population was used to quantify overall cumulative radiological transportation impacts. This measure was chosen because it could be related directly to latent cancer fatalities using a cancer risk coefficient and because of the difficulty in identifying a maximally exposed individual for shipments throughout the United States from 1943 through 2047. Operations at the Hanford Site and the Oak Ridge Reservation began in 1943, and 2047 is when the EIS analysis assumed that radioactive material shipments to the repository for Inventory Module 1 or 2 would end. The source of this cumulative transportation impacts analysis is the Yucca Mountain EIS Environmental Baseline File on transportation (TRW 1999u, Section 7.0), with the exception of impacts from the Proposed Action and Module 1 or 2, which are from Table 8-57.

The cumulative impacts of the transportation of radioactive material would consist of impacts from:

- Historic DOE shipments of radioactive material associated with the Nevada Test Site, the Idaho National Engineering and Environmental Laboratory, the Savannah River Site, the Hanford Site, the Oak Ridge Reservation, and naval spent nuclear fuel and test specimens

- Reasonably foreseeable actions that include the transportation of radioactive material identified in DOE Environmental Policy Act analyses; for example, the Nevada Test Site Environmental Impact Statement (DOE 1996f, all), the Department of Energy Spent Nuclear Fuel Management Environmental Impact Statement (DOE 1995a, all; DOE 1996c, all), and the Final Department of Energy Waste Management Environmental Impact Statement (DOE 1997b, all) (see Table 8-60). [Note: Table 8-60 includes reasonably foreseeable projects that include limited transportation of radioactive material (for example, shipment of submarine reactor components from the Puget Sound Naval Shipyard to the Hanford Site for burial, and shipments of uranium billets and low-specific-activity nitric acid from the Hanford Site to the United Kingdom). In addition, for reasonably foreseeable future actions where a preferred alternative was not identified or a Record of Decision has not been issued, the analysis used the alternative estimated to result in the largest transportation impacts. While this is not an exhaustive list of the projects that could include limited transportation of radioactive material, it indicates that the transportation impacts associated with such projects are low in comparison to major projects or general transportation.]

- General radioactive materials transportation that is not related to a particular action; for example, shipments of radiopharmaceuticals to nuclear medicine laboratories and shipments of commercial low-level radioactive waste to commercial disposal facilities

- Shipments of spent nuclear fuel, high-level radioactive waste, Greater-Than-Class-C waste, and Special-Performance-Assessment-Required waste under the Proposed Action or Inventory Module 1 or 2

Table 8-60 summarizes the worker and general population collective doses from the transport of radioactive material. The estimated total cumulative transportation-related collective worker doses from the mostly legal-weight truck shipments (past, present, and reasonably foreseeable actions) with the Proposed Action would be about 340,000 person-rem (140 latent cancer fatalities), and with Inventory Module 1 or 2 about 370,000 person-rem (150 latent cancer fatalities). The estimated total general population collective doses for the mostly legal-weight truck shipments would be about 340,000 person-rem (170 latent cancer fatalities) with the Proposed Action, and about 390,000 person-rem (200 latent cancer fatalities) with Module 1 or 2. Most of the collective dose for workers and the general population would be due to general transportation of radioactive material. The estimated total number (workers plus population) of latent cancer fatalities with the Proposed Action would be about 310, and about 350 with Module 1 or 2. Over a corresponding period from 1943 to 2033 for the Proposed Action and from 1943 to 2047 for Module 1 or 2, approximately 46 million and 54 million people, respectively, would die from cancer in the United States based on 510,000 annual cancer fatalities (Bureau of the Census 1993, all). The estimated number of transportation-related latent cancer fatalities would be indistinguishable from other cancer fatalities, and the transportation-related latent cancer fatalities would be less than 0.0007 percent of the total number of cancer fatalities.

For transportation accidents involving radioactive material, the dominant risk is due to accidents that are not related to the cargo (traffic or vehicular accidents). Typically, the radiological accident risk (latent cancer fatalities) from transportation accidents is less than 1 percent of the vehicular accident risk (see Table 8-58). In addition, no acute radiological fatalities due to transportation accidents have ever

Table 8-60. Cumulative transportation-related radiological collective doses, latent cancer fatalities, and traffic fatalities.[a]

Category	Collective worker dose (person-rem)	Collective general population dose (person-rem)	Traffic fatalities
Historical DOE shipments (DOE 1996f, all)	330	230	NL[b]
Reasonably foreseeable actions			
Nevada Test Site expanded use (DOE 1996f, all)	--[c]	150[d]	8
Spent nuclear fuel management (DOE 1995a, all; DOE 1996c, all)	360	810	0.77
Waste Management PEIS (DOE 1997b, all)[e]	16,000	20,000	36
Waste Isolation Pilot Plant (DOE 1997o, all)	790	5,900	5
Molybdenum-99 production (DOE 1996j, all)	240	520	0.1
Tritium supply and recycling (DOE 1995e, all)	--	--	0.029
Surplus HEU disposition (DOE 1996k, all)	400	520	1.1
Storage and Disposition of Fissile Materials (DOE 1996e, all)	--	2,400[d]	5.5
Stockpile Stewardship (DOE 1996l, all)	--	38[d]	0.064
Pantex (DOE 1996m, all)	250[f]	490[d]	0.006
West Valley (DOE 1996b, all)	1,400	12,000	3.6
S3G and D1G prototype reactor plant disposal (DOE 1997q, all)	2.9	2.2	0.010
S1C prototype reactor plant disposal (DOE 1996n, all)	6.7	1.9	0.0037
Container system for Naval spent nuclear fuel (USN 1996a, all)	11	15	0.045
Cruiser and submarine reactor plant disposal (USN 1996b, all)	5.8	5.8	0.00095
Submarine reactor compartment disposal (USN 1984, all)	--	0.053	NL
Uranium billets (DOE 1992b, all)	0.50	0.014	0.00056
Nitric acid (DOE 1995h, all)	0.43	3.1	NL
General radioactive material transportation			
1943 to 2033	310,000	260,000	19
1943 to 2047	330,000	290,000	22
Proposed Action			
Mostly legal-weight truck	11,000	35,000	3.9
Mostly rail	1,900 - 2,300	3,300 - 5,000	3.6
Module 1 or 2[g]			
Mostly legal-weight truck	20,000	62,000	7.0
Mostly rail	3,100 - 3,800	5,000 - 8,100	6.2
Total collective dose (total latent cancer fatalities)[h] *and total traffic fatalities*			
Proposed Action			
Mostly legal-weight truck	340,000 (140)	340,000 (170)	83
Mostly rail	330,000 (130)	310,000 (160)	83
Module 1 or 2[g]			
Mostly legal-weight truck	370,000 (150)	390,000 (200)	86
Mostly rail	350,000 (140)	340,000 (170)	85

a. Sources: TRW (1999u, Section 7) except for the Proposed Action and Inventory Module 1 or 2, which are from Table 8-56. All references in this table refer to the original source of information cited in TRW (1999u, Section 7).
b. NL = not listed.
c. -- = reported or included with the general population collective dose.
d. Includes worker and general population collective doses.
e. Includes mixed low-level waste and low-level waste; transuranic waste included in DOE (1997o, Volume 1).
f. Includes all highly enriched uranium shipped to Y-12.
g. The transportation-related radiological collective doses for Inventory Module 1 or 2 include the doses from the Proposed Action (see the definition of Modules 1 and 2 in Section 8.1.2.1).
h. The conversion factors for worker and general population collective dose to latent cancer fatalities are 0.0004 and 0.0005 latent cancer fatality per person-rem, respectively (NCRP 1993a, page 31).

occurred in the United States. Therefore, the number of vehicular accident fatalities was used to quantify the cumulative impacts of transportation accidents.

From 1943 through 2033 an estimated 4 million people would be killed in motor vehicle accidents and 180,000 people would be killed by railroad accidents. From 1943 through 2047, an estimated 4.4 million people would be killed in motor vehicle accidents and 200,000 people would be killed in railroad accidents. Based on the estimated number of traffic fatalities for the reasonably foreseeable actions and for the Proposed Action and Inventory Module 1 or 2 listed in Table 8-60, the transport of radioactive material would contribute about 100 fatalities to these totals.

8.4.2 NEVADA TRANSPORTATION

This section analyzes potential cumulative impacts that Inventory Module 1 or 2 and past, present, and other reasonably foreseeable future Federal, non-Federal, and private actions could have on the construction and operation of a branch rail line or the construction and operation of an intermodal transfer station and associated highway upgrades for heavy-haul trucks in the State of Nevada. The analysis included potential cumulative impacts in the vicinity of the five potential branch rail line corridors, the three potential intermodal transfer station locations, and the five associated potential highway routes for heavy-haul trucks.

With respect to potential cumulative impacts from Inventory Module 1 or 2, there would be no cumulative construction impacts because the need for a new branch rail line or new intermodal transfer station and associated highway upgrades for heavy-haul trucks would not change; that is, whatever DOE would build for the Proposed Action would also serve Module 1 or 2. In addition, because the planned annual shipment rate of spent nuclear fuel and high-level radioactive waste to the Yucca Mountain Repository would be about the same for Module 1 or 2 and the Proposed Action, the only cumulative operations impacts would result because of the extra 14 years of shipping time required for Module 1 or 2. With this basis, the operation and maintenance of a branch rail line or an intermodal transfer station and associated highway route for heavy-haul trucks were analyzed for potential cumulative impacts from Module 1 or 2.

Land-use and ownership impacts would be unlikely for the Proposed Action (see Chapter 6, Section 6.3), and DOE expects no cumulative impacts from extending shipping operations from approximately 24 to 38 years. Similarly, DOE expects no cumulative impacts from the extended 14 years of operation for Inventory Module 1 or 2 to air quality; hydrology (surface water and groundwater); biological resources and soils; cultural resources; socioeconomics; noise; aesthetics; and utilities, energy, and materials, the impacts of which were assessed on a per shipment, weekly, or annual basis (see Chapter 6, Section 6.3).

Cumulative impacts from Inventory Module 1 or 2 to occupational and public health and safety are included in the occupational and public health and safety impacts of national transportation in Section 8.4.1. The operation of an intermodal transfer station for more years under Module 1 or 2 would affect waste management impacts. The same waste types and annual quantities would be generated as for the Proposed Action, but the total waste quantities would be about 60 percent more than those for the Proposed Action due to the additional years of operation. However, the small waste quantities generated for Module 1 or 2 would have a minimal impact to the receiving treatment and disposal facilities. Because there would be no large cumulative impacts for any of the resource areas from Module 1 or 2, disproportionately high and adverse cumulative impacts to minority or low-income populations or to Native Americans would be unlikely.

Other than Inventory Module 1 or 2, one other Federal action and several private actions could have the potential for cumulative impacts with the construction and operation of a new branch rail line or intermodal transfer station and associated highway route for heavy-haul trucks.

One private action that could lead to cumulative impacts with the Carlin rail corridor implementing alternative is by Cortez Gold Mine, Inc., which has an existing Pipeline Project mining operation and processing facility (BLM 1996, all), a proposed Pipeline Infiltration Project (BLM 1999b, all), and a possible Pipeline Southeast Expansion Project (BLM 1996, page 5-7) in the Crescent Valley area of Nevada through which the Carlin branch rail line would pass (see Section 8.1.2.3 and Figure 8-4). Because the Carlin corridor would pass through the general area of these projects, there could be cumulative land-use and ownership impacts that would require mitigation. Because the Pipeline Southeast Expansion Project is currently under study, the Final EIS will review new information that

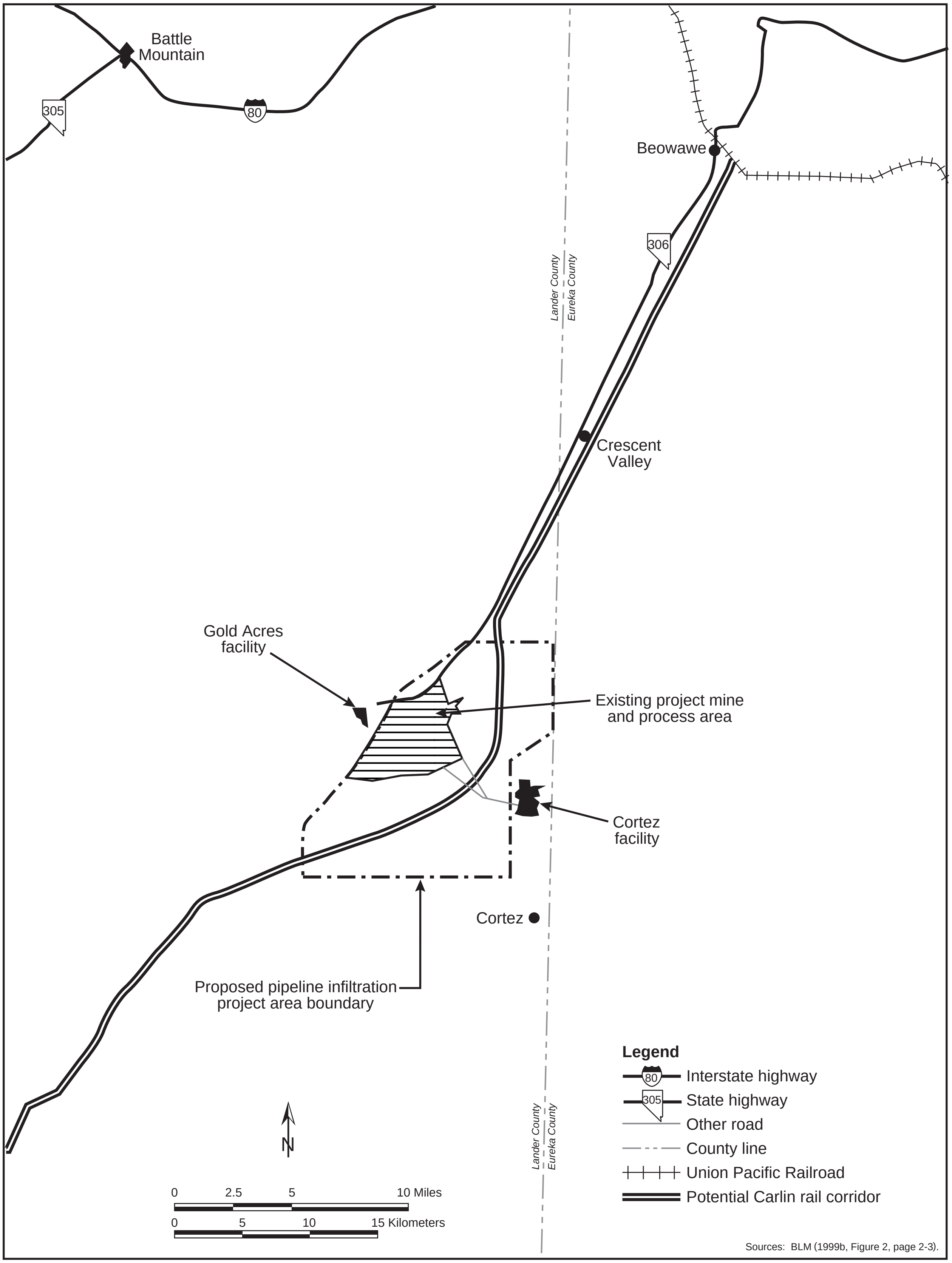

Figure 8-4. Cortez Gold Mine existing pipeline project and proposed pipeline infiltration project.

becomes available on this project for additional cumulative impacts. The analysis for the Carlin rail corridor represents the maximum impact other rail corridor implementing alternatives would have smaller impacts. Cumulative impacts for the mostly legal-weight truck scenario would also have smaller impacts.

Another private action that could result in cumulative impacts would be shared use of a branch rail line that DOE constructed and operated to transport spent nuclear fuel and high-level radioactive waste to the Yucca Mountain Repository by others (for example, mine operators, private freight shippers) because of the increased rail traffic. Because predicting the increase in rail traffic would be difficult, this analysis cannot estimate the cumulative impacts. There could be some added impacts to all the resource areas beyond those evaluated for the Proposed Action in Chapter 6, but there would also be benefits from the improved economic potential for resource development in interior areas of Nevada as well as greater economic development potential for nearby communities. DOE would have to consider these impacts in any decision it made to allow shared use of the branch rail line.

A Federal action and a private action could lead to cumulative impacts with the construction and operation of the Caliente intermodal transfer station. DOE has specified the Caliente site as one of four possible locations for the construction and operation of an intermodal transfer station for the shipment of low-level radioactive waste to the Nevada Test Site (DOE 1998m, pages 2-4 to 2-12). In addition, a commercial venture planned by Apex Bulk Commodities for the Caliente site would construct an intermodal transfer station for the transport of copper concentrate. Figure 8-5 shows a possible layout plan for these intermodal transfer stations at Caliente. Section 8.1 provides more information on the potential DOE and Apex intermodal transfer stations. The following sections describe the potential cumulative impact analysis at the Caliente site from the construction and operation of an intermodal transfer station to support the proposed Yucca Mountain Repository, coupled with an intermodal transfer station for shipment of low-level radioactive waste to the Nevada Test Site and an intermodal transfer station proposed by Apex Bulk Commodities.

8.4.2.1 Land Use and Ownership

The land required for the DOE low-level radioactive waste and Apex intermodal transfer stations would add to the approximately 0.21 square kilometer (50 acres) of property that would be required for the intermodal transfer station that would support the proposed Yucca Mountain Repository. The rail spur and facility for the low-level radioactive waste intermodal transfer station would disturb approximately 0.02 square kilometer (5 acres) of land. The Apex transfer facility would be in a building about 90 by 30 meters (300 by 100 feet). In addition, Apex would have a truck maintenance facility in a building about 30 by 18 meters (100 by 60 feet) that it could share with the low-level radioactive waste intermodal facility. The incremental impacts resulting from the changes in land use associated with the three intermodal transfer stations would not result in a substantial cumulative impact.

8.4.2.2 Air Quality

Air quality cumulative impacts during construction of the three intermodal transfer stations would not be expected to occur since construction activities would likely occur at different times. Even if construction for all three intermodal transfer stations occurred concurrently, administrative controls would be implemented to prevent an adverse impact from collective emissions and dust-generating activities.

During operations, there would be approximately one or two repository rail shipments and three or four associated heavy-haul trucks a day, an average of about three trains and seven trucks a day for DOE low level radioactive waste shipments, and one truck an hour for the Apex copper concentrate transport. At present, an average of one train an hour and light highway traffic travels through Caliente. The incremental increase in air pollutants from rail and highway traffic resulting from the three actions would

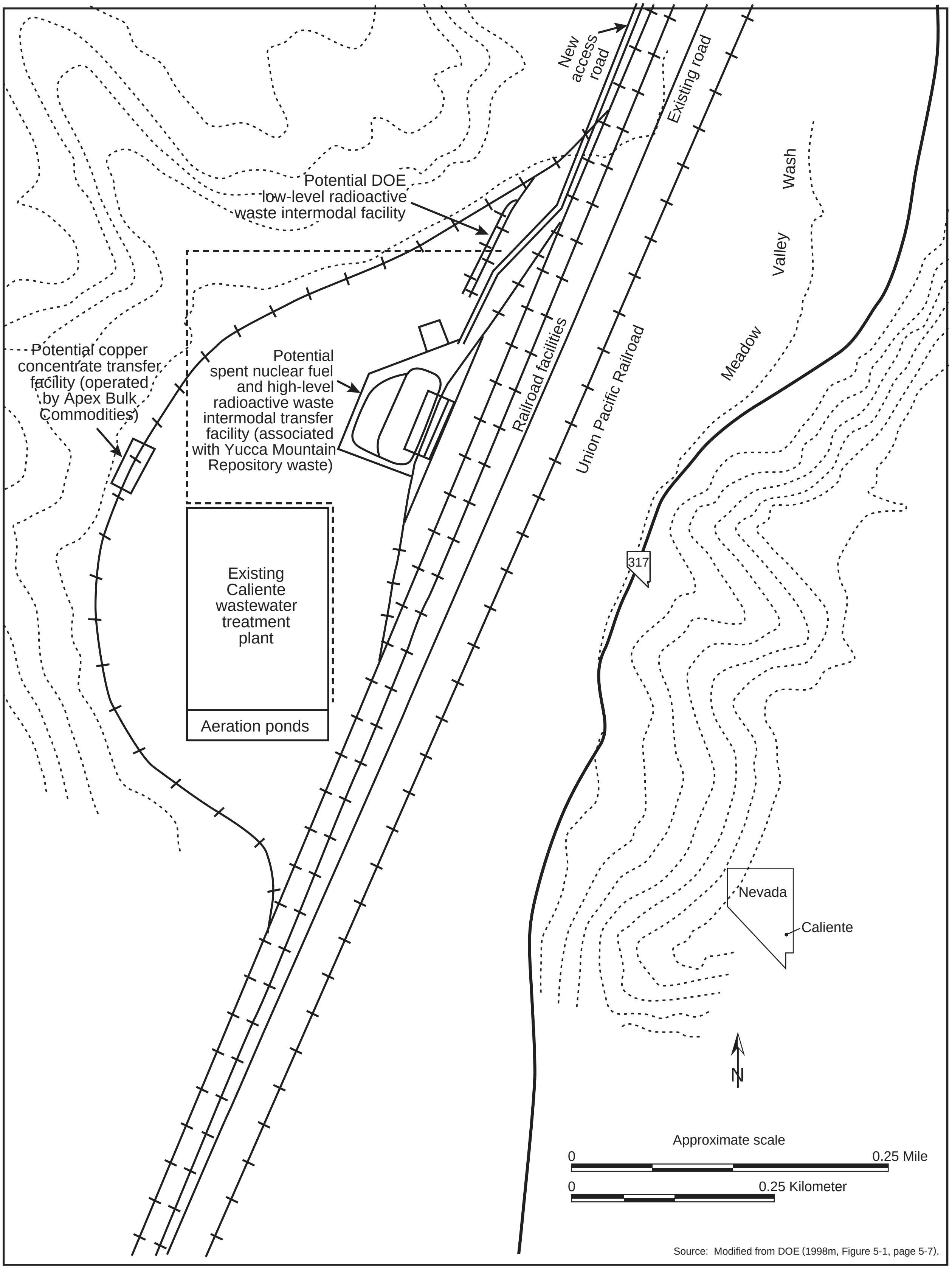

Figure 8-5. Potential locations of intermodal transfer stations at Caliente.

cause slight, temporary increases in pollutants, but would not exceed Federal standards (Chapter 6, Section 6.3.2; DOE 1998m, pages 4-13, 5-5, and 5-8). Criteria pollutants released during routine operations of the intermodal transfer stations would include nitrogen dioxide, sulfur dioxide, carbon monoxide, and particulate matter. DOE expects these emissions would also be well within Federal standards.

8.4.2.3 Hydrology

Surface Water

Mitigation measures used during the construction of the intermodal transfer stations would minimize surface-water impacts. Floodplain impacts probably would occur if DOE selected the Caliente intermodal transfer station (see Appendix L). If that location was selected, DOE would conduct a detailed floodplain/wetland assessment and integrate good construction practices to minimize impacts. Construction probably would involve some permanent drainage alterations. Runoff rates would differ from natural or existing terrain but, given the relatively small size of the area, there would be little effect on overall runoff quantities for the area (Chapter 6, Section 6.3.3.1; DOE 1998m, pages 4-13 and 5-8). DOE expects very small impacts to surface waters during the construction and operation of the stations.

Groundwater

Construction activities for the intermodal transfer stations would disturb and loosen the ground for some time, which could result in higher infiltration rates. However, these activities and their resultant short-term impacts probably would occur at different times for the three stations. The relatively small sizes of the three facilities would minimize changes in groundwater infiltration rates during operations. Potential sources of contamination would include one to three diesel fuel tanks for the standby generators and heavy equipment for all three stations. The small overall water demand could be met by installing wells or by existing water distribution systems. In addition, the operation of the Apex copper concentrate and DOE low-level radioactive waste intermodal transfer station would only overlap with the beginning years of spent nuclear fuel and high-level radioactive waste shipment to the proposed Yucca Mountain Repository.

8.4.2.4 Biological Resources and Soils

The proposed locations of the intermodal transfer stations are in an irrigated pasture area that is partly wetland. However, because the area was modified as pasture and the native habitat has been degraded, cumulative impacts to biological resources would be low. Construction activities could lead to soil erosion. Water would be applied to suppress dust and compact soil. The operation of the stations would have small cumulative impacts on soils. Erosion damage control would be performed as necessary throughout the operational periods.

8.4.2.5 Cultural Resources

Impacts could occur to archaeological, historic, and traditional Native American cultural sites from the construction of the intermodal transfer stations. Cultural resource surveys of this portion of the Meadow Wash Area have identified two archaeological sites in the vicinity of the proposed DOE low-level radioactive waste intermodal site (DOE 1998m, pages 4-13). Neither site falls within the proposed intermodal transfer station areas. DOE would perform special ethnographic studies and archaeological surveys during the engineering design phases and before construction.

8.4.2.6 Socioeconomics

Employment levels for operation of the repository, Apex, and DOE low-level radioactive waste intermodal transfer stations would be 66, 25, and 14 employees, respectively (Chapter 6 and Section 8.1.2.2). Employment associated with the repository and low-level radioactive waste intermodal transfer stations includes operations personnel and truck drivers. Concurrent operations for all three stations would occur over a portion of the entire 24- or 38-year shipping period for the Proposed Action or Inventory Module 1 or 2, respectively. Employment levels would increase gradually to the maximum values listed above and then decrease gradually toward the end of emplacement activities for repository-related workers. Impacts to employment, population, personal income, Gross Regional Product, and state and local government expenditures during station operations would be small for Lincoln County (Chapter 6, Section 6.3.2.2; DOE 1998m, pages 4-14 and 5-9).

The truck traffic in the Caliente area would be increased from the three intermodal transfer stations. The small increase would have a very small impact on U.S. Highway 93, which would be used when entering and leaving the intermodal transfer station access road. U.S. 93 is currently characterized as having light traffic. The period of concurrent truck traffic from the three intermodal transfer stations would also occur only over a portion of the 24- or 38-year shipping duration for the Proposed Action or Inventory Module 1 or 2, respectively.

8.4.2.7 Occupational and Public Health and Safety

The incremental impacts resulting from an increase in radiological risk associated with the intermodal transfer stations for the repository and low-level radioactive waste shipments at Caliente would not result in a substantial cumulative impact. The estimated total collective worker dose from the entire DOE low-level radioactive waste intermodal shipping campaign, including transportation impacts, would be about 4.21 person-rem (DOE 1998m, page 4-10). This dose, added to the total repository intermodal transfer station and rail and heavy-haul truck shipments worker dose of about 530 to 550 person-rem for the Caliente intermodal transfer station for Inventory Module 1 or 2 (Appendix J, Table J-57) would be an increase of less than 3 percent. The population dose associated with low-level radioactive waste shipments by truck from the intermodal transfer station would be 7.55 person-rem for the entire shipping campaign (DOE 1998m, Table C-11, page C-23). This dose, added to the dose from shipments in Nevada that use heavy-haul trucks of 1,400 person-rem over 38 years, would increase the population dose and associated health effects by less than 1 percent.

8.4.2.8 Noise

There would be an increase in noise levels at the Caliente Site from the three intermodal transfer stations and the associated train switching operations and truck traffic. Noise levels would increase during daytime and night hours for rail activities and during daytime hours for truck shipment activities associated with the repository heavy-haul trucks and the DOE low-level radioactive waste trucks. Apex truck shipments would occur once an hour, 24 hours a day. Noise associated with railcar shipments would occur as the railcars were uncoupled from trains and transferred in and out of the stations, which could occur during the day or night. Elevated noise levels would occur during loading and unloading operations and briefly as trucks passed on the highway. Trucks would not travel through Caliente for shipments to either Yucca Mountain or the Nevada Test Site. Overall, the elevation of noise levels associated with rail and truck activity near a level that would cause concern would be unlikely. In addition, due to the location of the intermodal transfer stations in an uninhabited canyon area, noise impacts from rail and truck loading and unloading would be low. Cumulative effects would also be limited because operations at the DOE low-level radioactive waste and Apex intermodal transfer stations would overlap only a portion of the shipping campaign associated with the proposed repository.

8.4.2.9 Aesthetics

The alteration of the landscape immediately surrounding the Class II lands [within about 8 kilometers (5 miles) of the Kershaw-Ryan State Park] could exceed the Class II objective. Class II designation by the Bureau of Land Management could require retention of the existing character of the landscape. However, the area proposed for the intermodal operations has been classified as Class III, which would require partial retention of the existing character of the landscape. The intermodal facilities would not greatly alter the landscape more than the current passing trains and sewage treatment operations. Public exposure would be limited due to obstruction by natural vegetation. Therefore, visual impacts would be very small (DOE 1998m, pages 4-12 and 5-8).

8.4.2.10 Utilities, Energy, and Materials

Electric power lines with adequate capacity are available near the site. Electric power, water supply, and sewage disposal facilities are currently provided to the sewage treatment facility near the proposed location of the intermodal transfer stations (DOE 1998m, page 4-12). Therefore, cumulative impacts to utilities would be small. The quantities of concrete, asphalt, and steel needed to build the intermodal facilities (associated mostly with the repository intermodal transfer station) would be unlikely to affect the regional supply system.

8.4.2.11 Management of Intermodal Transfer Station-Generated Waste and Hazardous Materials

The expected quantities of sanitary waste, small amounts of hazardous waste, and low-level radioactive waste associated with radiological surveys would be unlikely to have large impacts to landfill, treatment, and disposal facilities available for use by this site. Therefore, cumulative impacts for waste management would be small. Only limited quantities of hazardous materials would be needed for station operations, and DOE does not expect these needs to affect the regional supply system (DOE 1998m, pages 4-12, 4-13, and 5-8).

8.4.2.12 Environmental Justice

Because there would be no large cumulative impacts to human health and safety from the construction or operation of the intermodal transfer stations, there would be no disproportionately high and adverse impacts to minority and low-income populations. The absence of large cumulative environmental impacts for the general population means that there would be no disproportionately high and adverse environmental impacts for the minority or low-income communities. An evaluation of subsistence lifestyles and cultural values confirms these general conclusions. The foregoing conclusions and evaluations and the commitment by DOE to ensure minimal impacts to cultural resources show that construction and operation of the intermodal transfer stations would not be expected to cause or contribute to disproportionately high and adverse impacts to Native Americans (DOE 1998m; pages 4-14 and 5-9).

8.5 Cumulative Manufacturing Impacts

This section describes potential cumulative environmental impacts from the manufacturing of the disposal containers and shipping casks required to emplace Inventory Module 1 or 2 in the proposed Yucca Mountain Repository. No adverse cumulative impacts from other Federal, non-Federal, or private actions have been identified because no actions have been identified that, when combined with the Proposed Action or Inventory Module 1 or 2, would exceed the capacity of existing manufacturing facilities.

The overall approach and analytical methods and the baseline data used for the evaluation of cumulative manufacturing impacts for Inventory Module 1 or 2 were the same as those discussed in Section 4.1.14 for the Proposed Action. The evaluation focused on ways in which the manufacturing of the disposal containers and shipping casks could affect environmental resources at a representative manufacturing site and potential impacts to material sources and supplies.

Table 8-61 lists the total number of disposal containers and shipping casks required for the Proposed Action and Inventory Modules 1 and 2. As listed, the total number would increase by approximately 70 to 80 percent for Modules 1 and 2 in comparison to the Proposed Action. The highest total number of disposal containers and shipping casks would be for the Module 2 disposable canister packaging scenario, and this was the number used in the cumulative impact analysis. The number of disposal containers and shipping casks would not vary with the thermal load scenarios.

Table 8-61. Number of disposal containers and shipping casks required for the Proposed Action and Inventory Modules 1 and 2.

	Proposed Action			Module 1			Module 2		
Components	UC[a]	DISP[b]	DPC[c]	UC	DISP	DPC	UC	DISP	DPC
Disposal containers[d]	10,000	11,000	10,000	17,000	20,000	17,000	18,000	20,000	18,000
Shipping casks[e,f]									
Legal-weight truck	119	11	11	241	17	17	241	17	17
Railcar	0	98	98	0	175	175	0	195	175

a. UC = uncanistered packaging scenario.
b. DISP = disposable canister packaging scenario.
c. DPC = dual-purpose canister packaging scenario.
d. Source: TRW (1999c, all).
e. Shipping casks include transportation overpacks.
f. Sources: Chapter 4, Section 4.2; House (1999, all).

Based on the total number of disposal containers and shipping casks that would be required over a 38-year period for Inventory Module 1 or 2, the annual manufacturing rate would increase about 33 percent over that for the Proposed Action. Thus, the annual Module 1 or 2 impacts for air quality, socioeconomics, material use, and waste generation would be less than 20 percent higher than those discussed in Section 4.2 for the Proposed Action, and these impacts would continue for 38 years rather than the 24 years for the Proposed Action. The total number of worker injuries and illness or fatalities would increase in proportion to the increase in disposal containers and shipping casks manufactured. The potential number of injuries and illnesses over the 38-year period for Module 1 or 2 would be about 500 and the estimated number of fatalities would be 0.24 (that is, no expected fatalities). As for the Proposed Action, there would be few or no impacts on other resources because existing manufacturing facilities would meet the projected manufacturing needs and new construction would not be necessary and environmental justice impacts (that is, disproportionately high and adverse impacts to minority or low-income populations) would be unlikely.